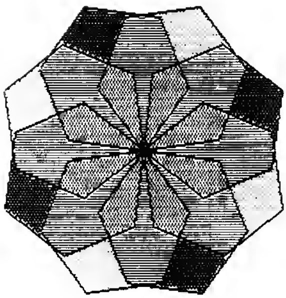
COLORING SERIES I™
GEOMETRIC DESIGNS

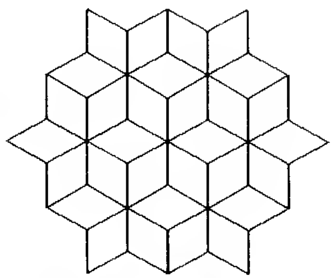
By David Thornburg

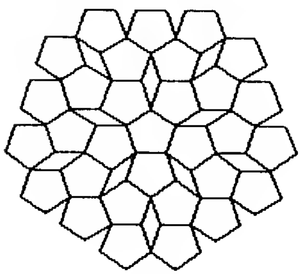
Coloring Series I: Geometric Designs

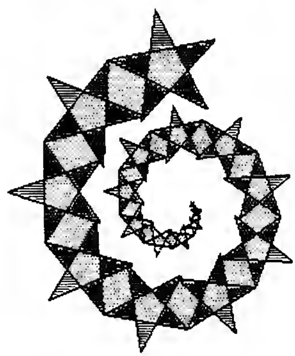
by

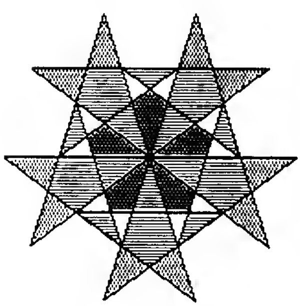
David D. Thornburg

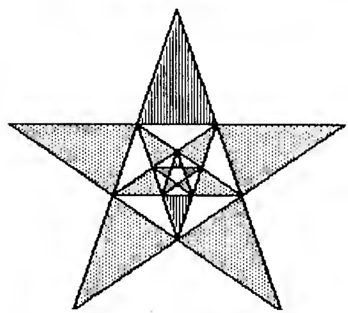












INTRODUCTION

Welcome to the first volume of the Koala Coloring Series. This book is designed to be used along with the accompanying diskette, the KoalaPad™ touch tablet and the KoalaWare™ drawing program packaged with the KoalaPad.

This volume of the Koala Coloring Series is a collection of 25 geometric designs that can be "colored" with the FILL command on the drawing program. We have also provided two copies of each picture in this book so you can color them with pencils, crayons, or water color pens. One experiment you might try is to pick a pattern that you will color both on the computer and in the book. Once you have finished coloring both forms of the picture, compare them. Which do you like better?

To use the enclosed diskette, follow the directions for retrieving a picture from a storage diskette as they appear in the drawing program manual or accompanying instruction sheet. Picture outlines can be retrieved by entering A1 to A25 when the computer asks for the name of the picture you see. (Pictures A1 through A13 are stored on the label side of the diskette and pictures A14 through A25 are stored on the other side.) After the desired picture outline has been loaded, re-insert the KoalaWare drawing program diskette, and you are ready to start coloring!

You may find that different color combinations can cause a given outline to take on new shapes each time it is colored. These patterns have been chosen to be fun to color over and over again. You probably will want to save your finished pictures on a separate storage diskette for later viewing.

While the pictures are fun to color, they also have other interesting properties. The rest of this manual describes some of these properties and suggests some experiments you might perform. You may find that these pictures open new insights to fields as diverse as art and mathematics.

But the most important thing is that you just enjoy experimenting!

Patterns and Symmetry in Geometric Designs

Geometric designs are everywhere. Mankind has been fascinated with them as far back as the Iron Age.

The almost mystical power of symmetric figures has accounted for their use in artifacts from religions all over the world. The tile patterns in the Alhambra and the stained glass of the Notre Dame Cathedral stand as only two of the myriad examples of the beauty to be found in geometry.

Symmetry and geometric form are commonplace in nature. To name just two examples, consider the beautiful spiral of a sea shell, or the arrangement of petals on a flower.

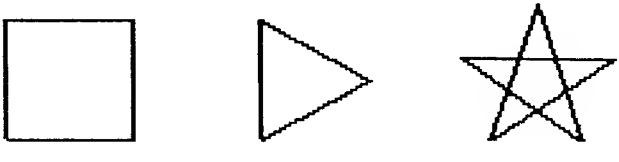
Symmetric geometric patterns are found all around the home as well - from patterns in tile floors to patterns on wallpaper and carpets.

Geometric patterns are an excellent topic for a coloring book. You may even find yourself creating patterns of your own, based on some ideas you may discover while using this book.

The patterns included in this book fall into three groupings. We will describe some of the properties of the pictures within each grouping and suggest experiments for you to try when coloring the pictures.

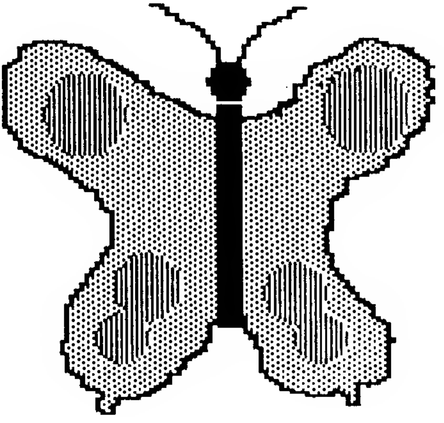
Group I - Polygons and Symmetry

When we think of geometric shapes, most of us probably think of shapes like squares, triangles and stars. Shapes like these are closed figures made from straight lines and are called polygons.



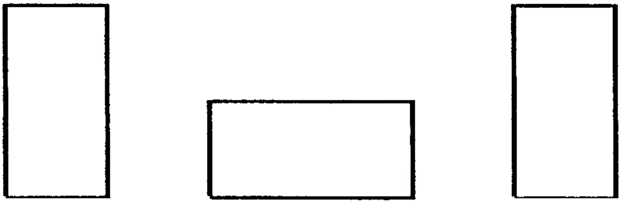
Polygons can be simple (like squares or triangles), or can be complex (like stars and other figures in which the lines cross). A polygon has many interesting properties relating to the number of sides it has, the values of its angles, and its symmetry.

When we think of something as being symmetric, most of us think about mirror symmetry, in which the left half of the object is a mirror reflection of the right half.



This is the type of symmetry we see in Butterflies.

In addition to mirror symmetry, there is another symmetry displayed by many figures - that of rotation. Rotational symmetry is seen easily in figures such as squares in which each rotation of the square by 90 degrees produces a figure that can't be distinguished from the original. If we rotate a rectangle by 90 degrees, it takes on a different appearance; but if we keep rotating it by an additional 90 degrees, it then can't be distinguished from its original orientation.



Because there are four equivalent angular orientations of a square, we say that the square has a four-fold rotational axis. A rectangle, on the other hand, has a two-fold rotational axis.

As you look at figure A1 through A8, you will find many examples of rotational symmetry. Perhaps the simplest of these is shown in the set of nested triangles in figure A1:

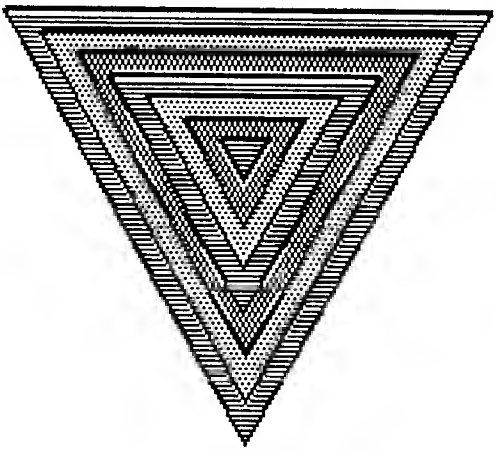


Figure A1

This figure can be seen as a set of nested triangles (a triangular "bull's eye"), but it can also be a picture of a stepped triangular pyramid. You should experiment by coloring this pattern in different ways to see if you can create both visual effects.

Figure A2 was made by drawing a hexagon at each of eight equally spaced angles around the center of the picture. While each hexagon has six-fold rotational symmetry, the overall figure has eight-fold symmetry.

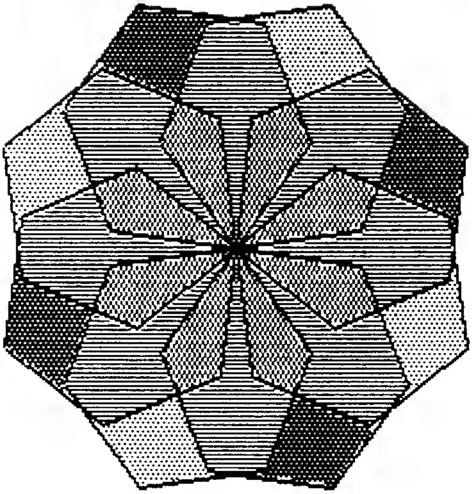


Figure A2

See if you can color this picture in such a way that the hexagons are almost impossible to detect.

The set of nested squares in figure A3 has a very interesting property. Start by coloring the central square and one small triangle. Next color the next larger triangle that is to the left of the small triangle. If you repeat this process you will create a spiral!

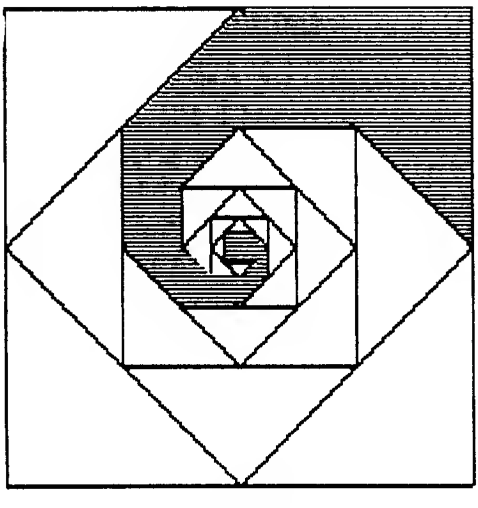


Figure A3

You should experiment to see how many different colored spirals you can create from this figure. Notice that before you started to color the figure it had four-fold rotational symmetry. Can you color it so it has only two-fold symmetry? Mirror symmetry? No symmetry at all? This figure is rich with possibilities.

Figure A4 was made by making five copies of a five-pointed star spaced at equal angles around the center of the picture. Because of the overlapping arms on the stars, several triangles and quadrilateral (four-sided) figures are created. One coloring exercise you might try is to color in all the regular pentagons (five-sided polygons with equal side lengths). There are six of them that I know of.

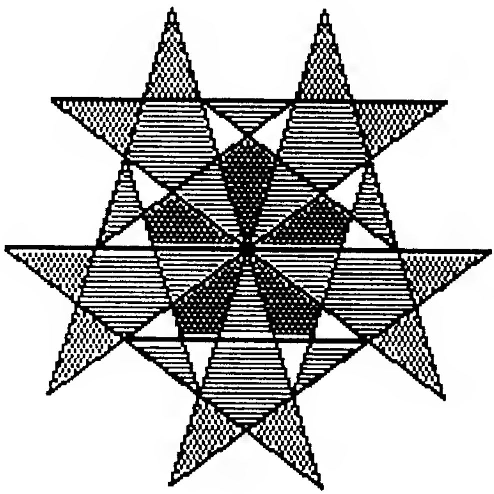


Figure A4

This figure also provides the opportunity to show that no more than four colors are needed to color a map so that no two adjoining areas have the same color. This "four color map theorem" defied proof for many years until recently when a team of mathematicians solved the problem with the aid of a computer.

Figure A5 shows a set of five-pointed stars with each star nested inside the pentagon formed by the next larger star.

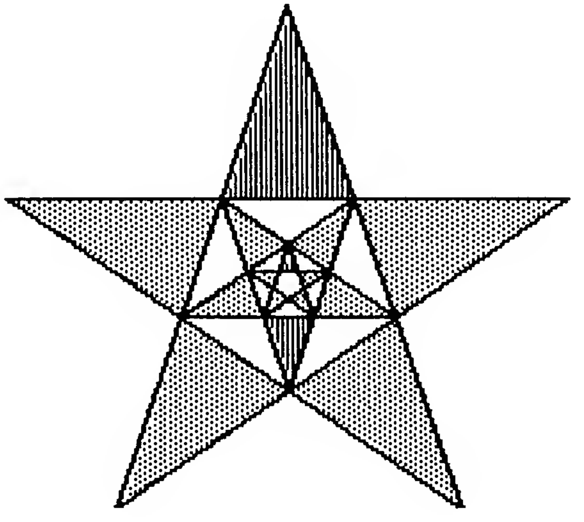


Figure A5

As you color this picture, imagine the nesting process being carried out to infinity!

You may have seen tile floors made from triangular, square, or hexagonal tiles. Figure A6 shows why you won't find tile floors made from regular pentagons - they don't fit together properly.

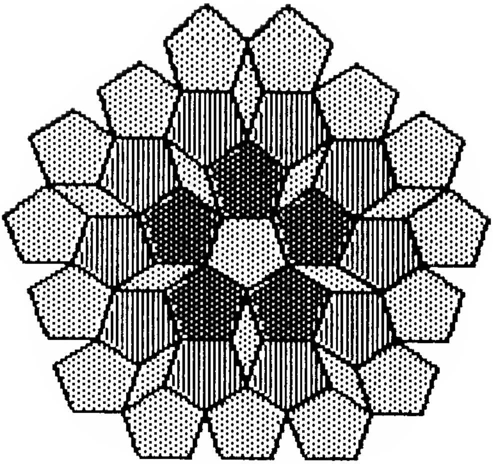


Figure A6

This figure gives you a chance to experiment with the illusion of three dimensional designs. By choosing your colors properly, you can made it appear that some of the pentagons are coming out of the page.

Even though regular pentagons don't make good floor tiles, there are other five-sided polygons that work quite well. The pattern in Figure A7 was made with one such tile.

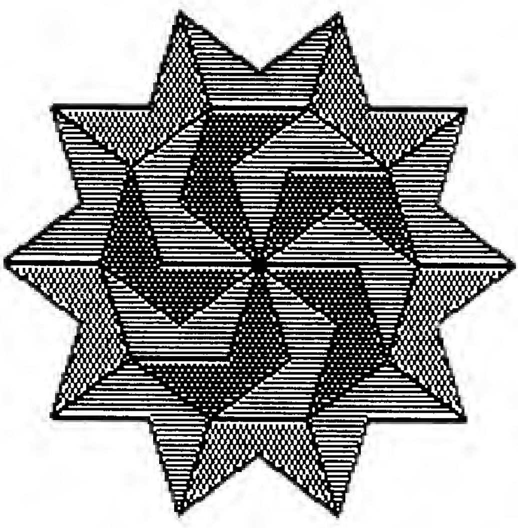


Figure A7

There are many such patterns, each with its own charm. The picture shown in figure A8 is one of the easiest with which to create the illusion of three-dimensional blocks.

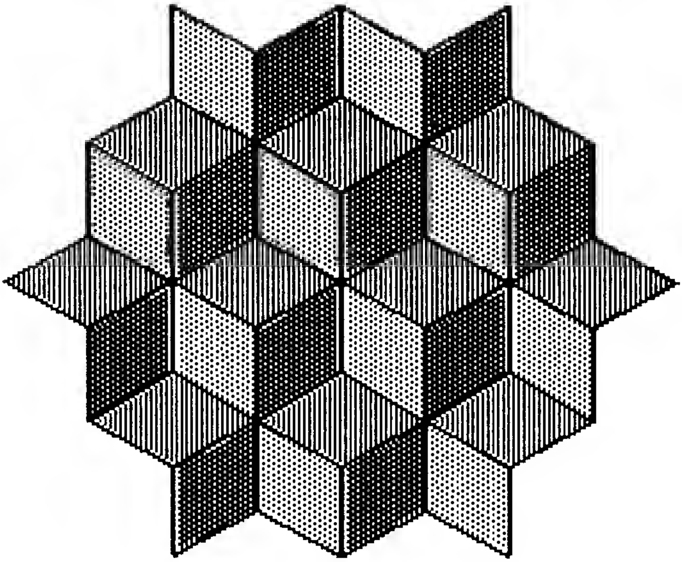


Figure A8

One challenge is to color this picture in such a way that this illusion disappears. It can be done.

Group II-Tilings

The next group of pictures consist of tiling patterns of the sort one might find in floor tiles, carpet patterns and quilts. All of these patterns were made from simple geometric forms, and yet they all have very distinctive characteristics.

The pattern in figure A9 was generated by repeating a simple "dog-leg" motif.

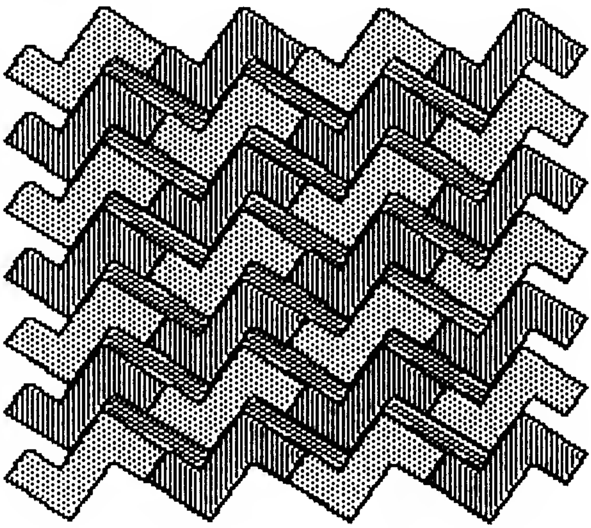


Figure A9

By not pressing the graphic elements as closely as they could fit, some rectangular areas are "left over".

Figure A10 was created entirely with triangles. By leaving some triangles out, a very interesting pattern results.

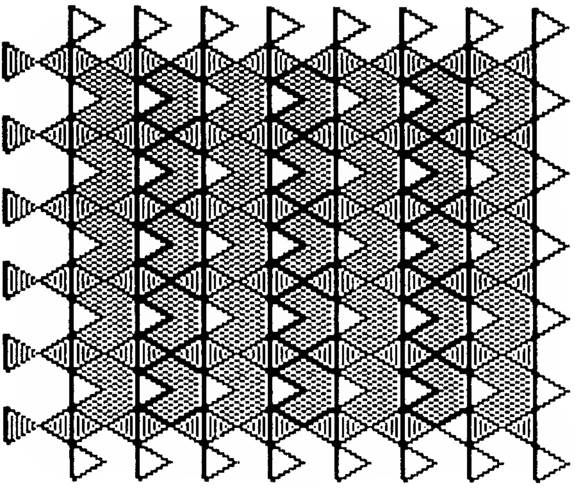


Figure A10

While the previous two figures were made by repeating a single motif, the building block for figure A11 is a bit more complex.

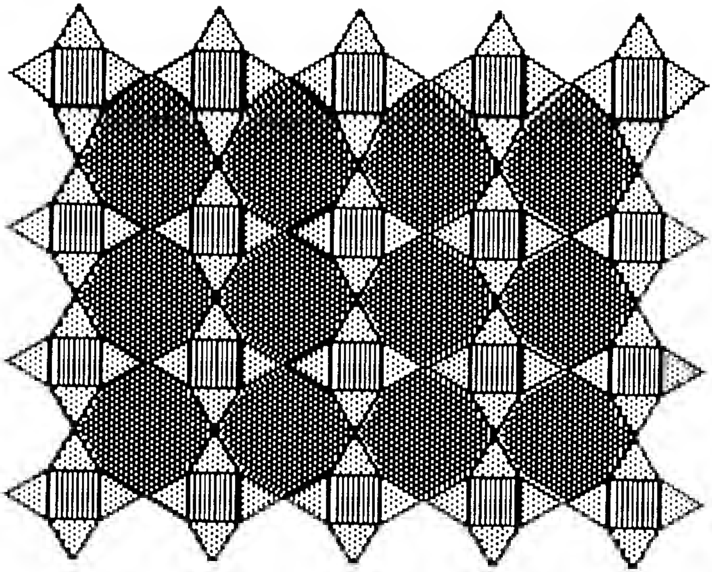


Figure A11

The basic building block for this figure is a square surrounded by four triangles. The resulting arrangement of this motif creates the large octagons that form a central part of the pattern.

Sometimes the repetition of a single pattern can create quite elaborate results. Fiqure A12 was created with overlapping octagons.

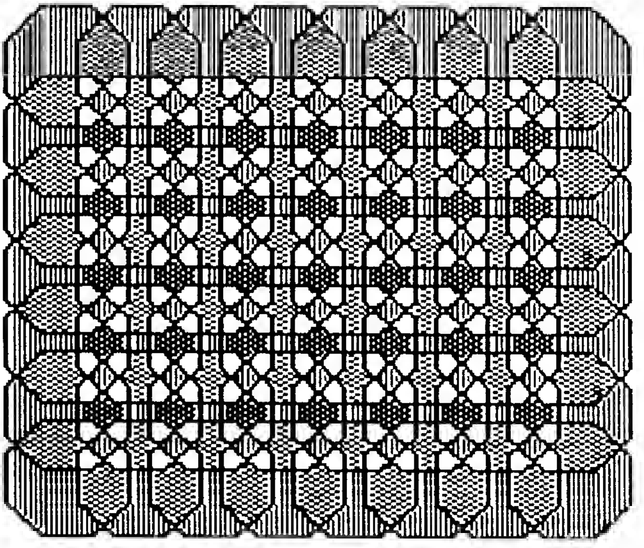


Figure A12

This pattern would look quite nice on a carpet.

While we already know that we can't tile a floor with regular pentagons, figure A13 shows that pentagons can be combined with dagger-shaped hexagons to create a nice set of tiles.

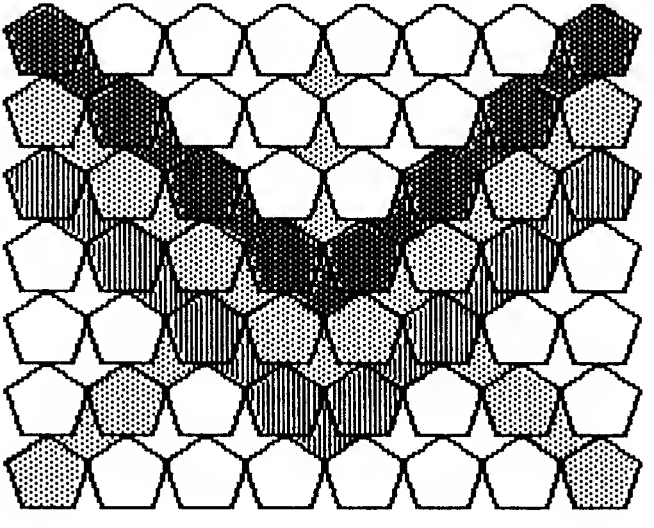


Figure A13

Just as a motif created from a square surrounded by four triangles can be used to create interesting patterns, the next two figures illustrate some patterns that result from a motif consisting of a square surrounded by four pentagons. In figure A14 the tips of the pentagons are just touching, and in figure A15 they overlap to create small diamonds.

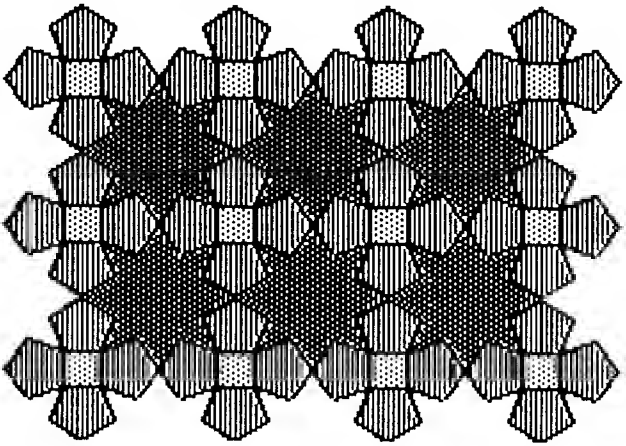


Figure A14

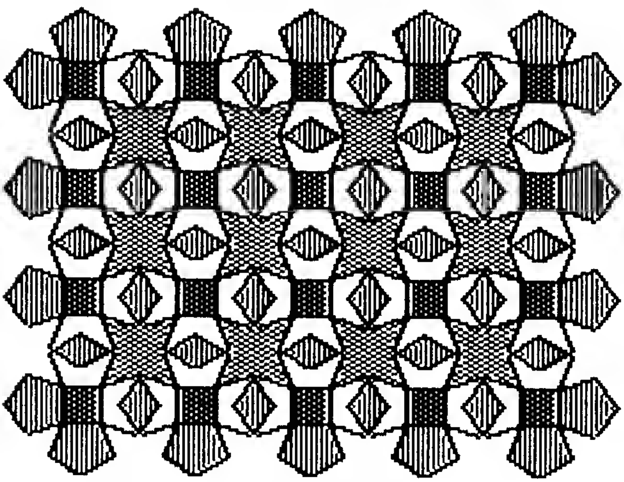


Figure A15

In figure A16 we switch to a motif consisting of a pentagon surrounded by five squares. The resulting pattern looks like a set of gingerbread men interlocked with birds.

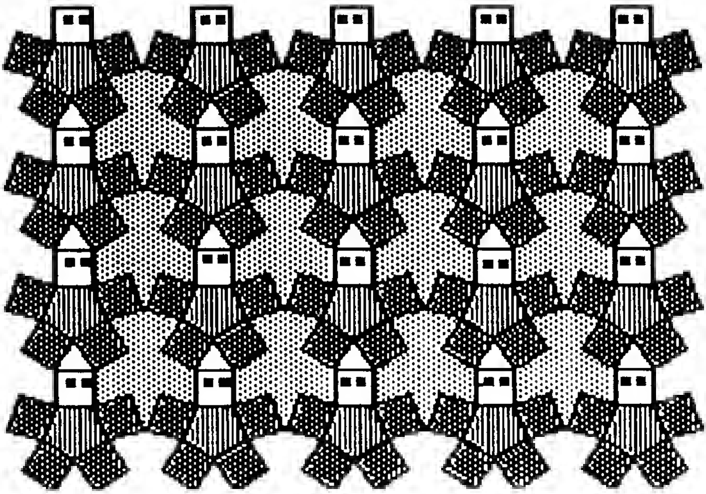


Figure A16

The famous artist M. C. Escher made extensive use of interlocking figures in his artwork. Interestingly, he was inspired to work in this area by his visit to see the Moorish mosaics in the Alhambra.

The use of a "Y" shaped motif in figure A17 produces a simple pattern with many possibilities for further development.

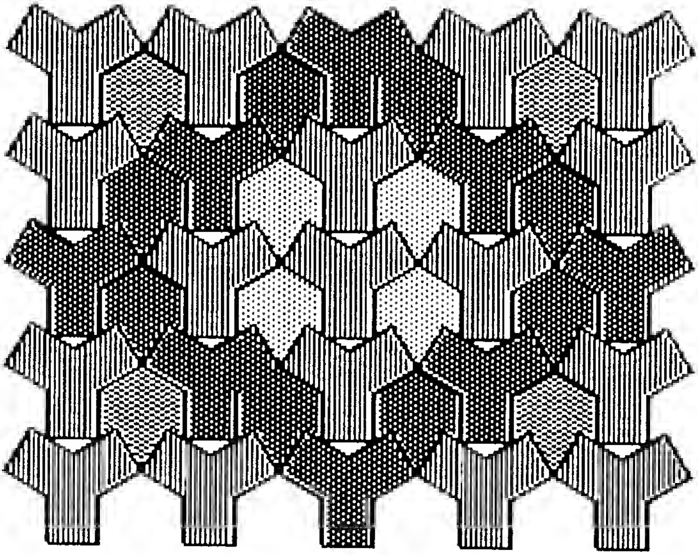


Figure A17

By repeating this motif four times and overlapping the ends a bit, we can generate a much more complex pattern such as that in figure A18.

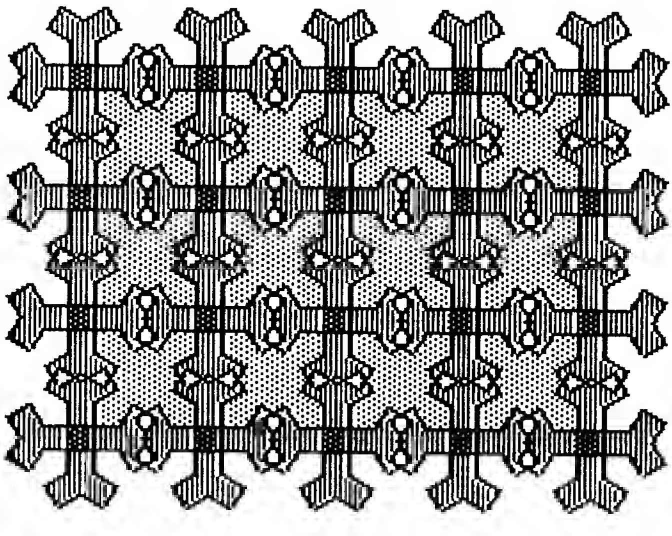


Figure A18

More elaborate patterns can produce designs that nearly interlock (as in figure A19) or which interlock perfectly (as in figure A20).

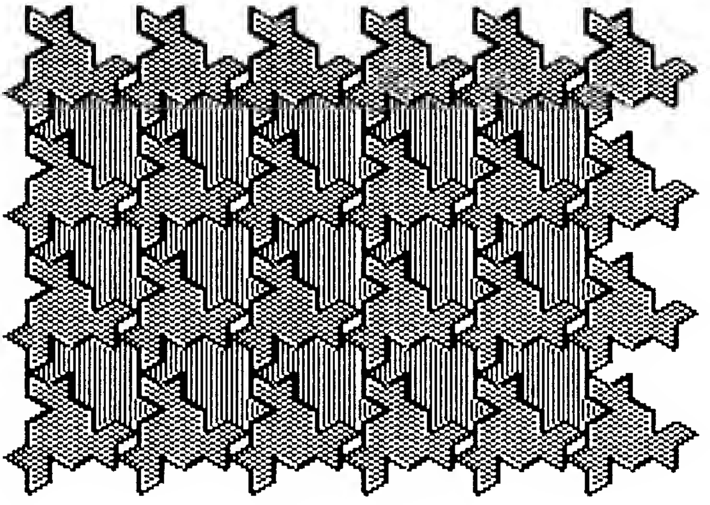


Figure A19

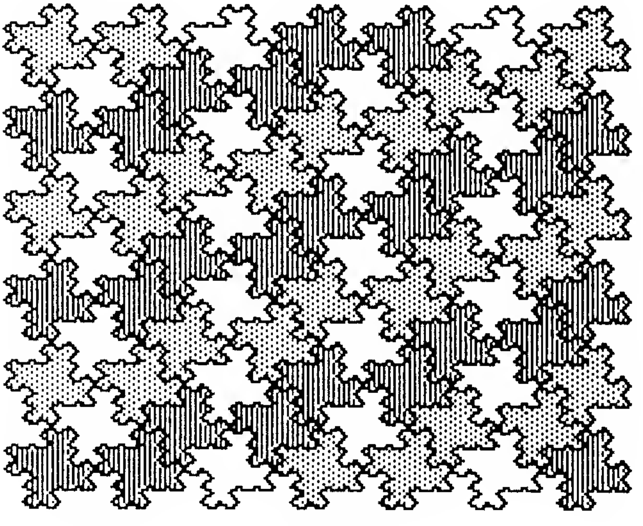


Figure A20

While complex patterns provide a challenge of their own, a simple array of circles such as shown in figure A21 is rich with coloring possibilities.

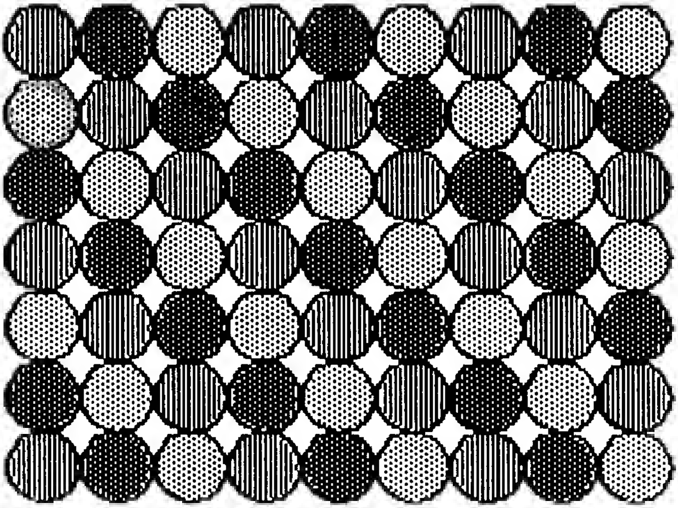


Figure A21

A wavy pattern made from alternating semicircles (figure A22) can be quite a challenge to color!

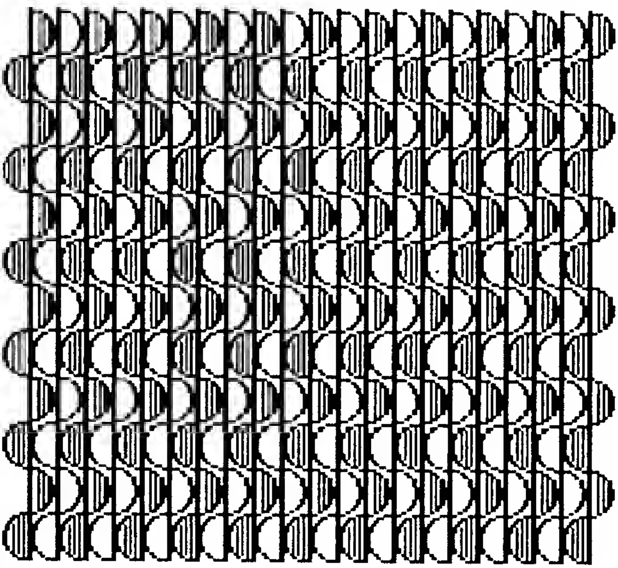


Figure A22

Group III - Spirals

Naturally occurring spirals are almost exclusively the domain of living things. From sea shells to pine cones, the appearance of the spiral suggests continuing growth. The use of repeated geometric forms to create spirals can produce interesting results. This section shows only a tiny sample of the possible patterns that one might devise.

Figure A23 was constructed from a chain of stars in which each star is larger than its predecessor by a fixed amount.

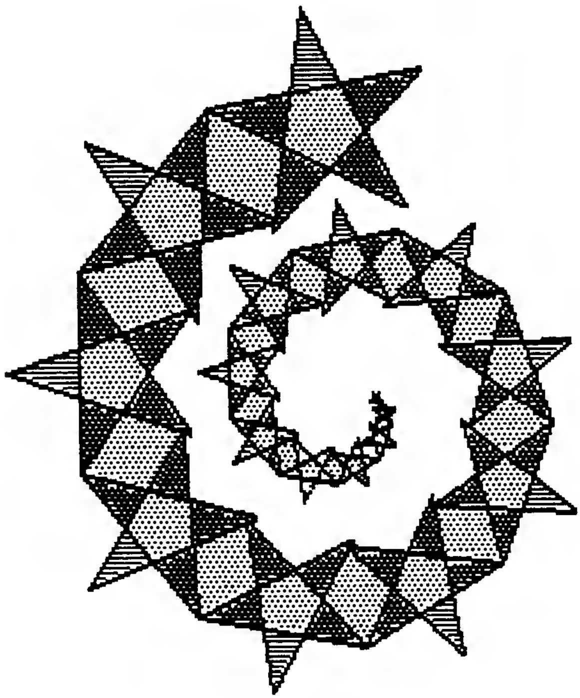


Figure A23

A challenge in creating this pattern was to choose the turning angle so that the tip of each star would point to the bottom of the star above it.

Figure A24 illustrates an interference phenomenon called a moiré effect.

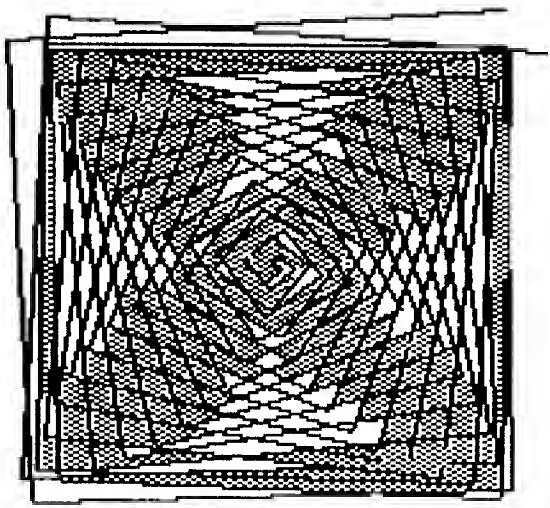


Figure A24

The four petal lobes resulted from overlaying two square spirals on top of each other. Each spiral had a slightly different turning angle than the other one.

Figure A25 was made by creating a set of overlapping "trees" that produced a fan similar to a peacock's tail.

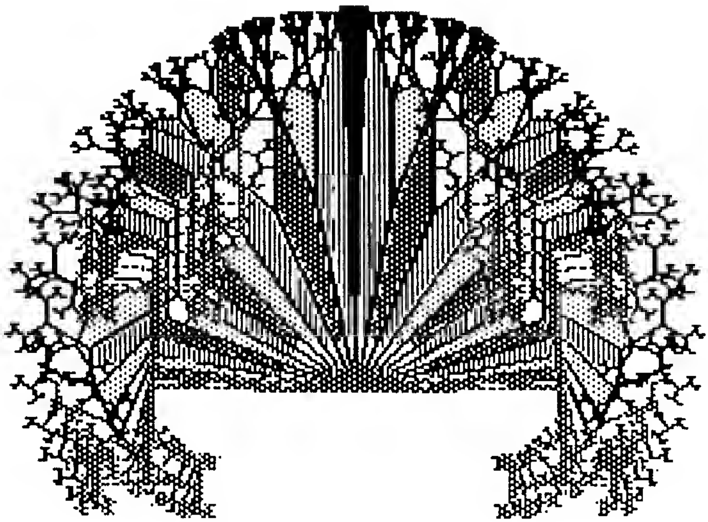


Figure A25

Notes on the Illustrations

All the illustrations for this book were created with computer programs written in Logo. While most of the figures were created by the author, figure A25 was created by Harvey, the author's nine-year-old son.

If you are interested in studying these patterns in more detail, the following book list (highly incomplete) should get you started.

S. Bezuszka, M. Kenney, and L. Silvey, *Tesselations: The Geometry of Patterns,* Creative Publications, 1977.

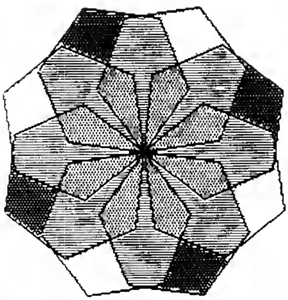
E. Holiday, *Altair Designs,* Pantheon, 1970.

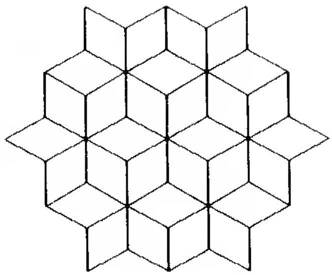
C. Macgillavry, *Fantasy and Symmetry - the Periodic Drawings of M.C. Escher,* Abrams, 1976.

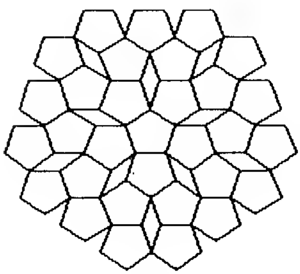
P. Stevens, *Handbook of Regular Patterns - An Introduction to Symmetry in Two Dimensions,* MIT Press, 1981.

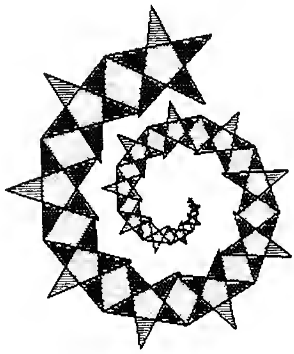
D. Thornburg, *Discovering Apple Logo - An Invitation to the Art and Pattern of Nature,* Addison Wesley, 1983.

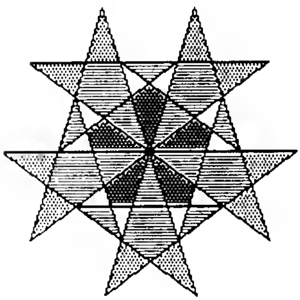
The Figures

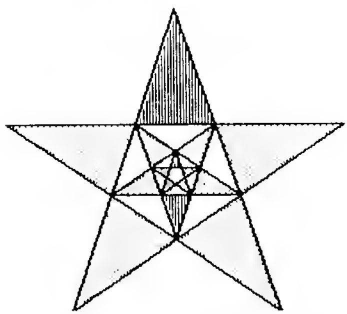


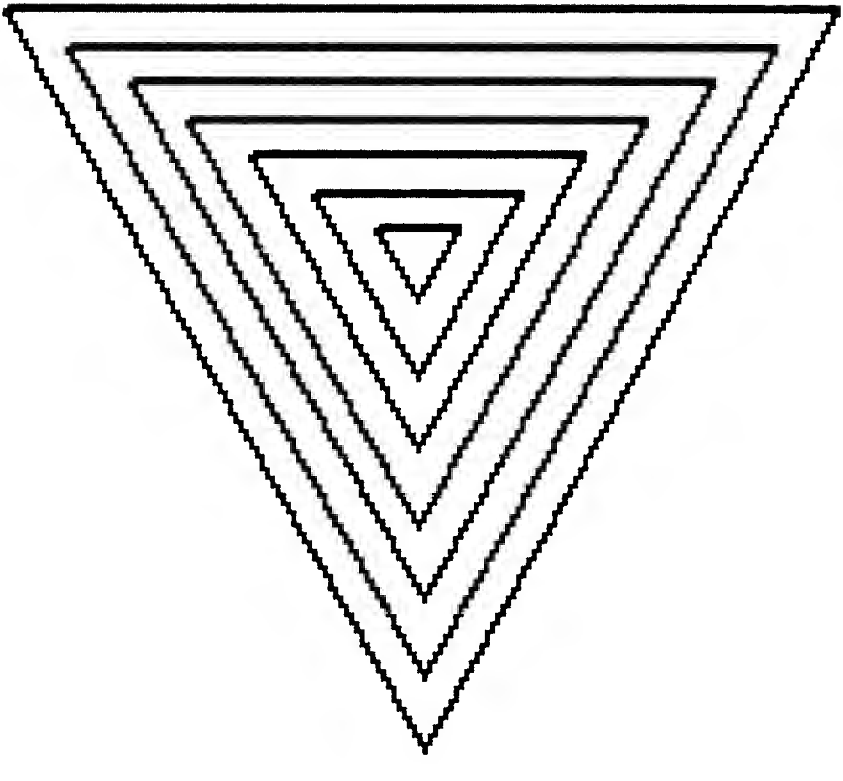


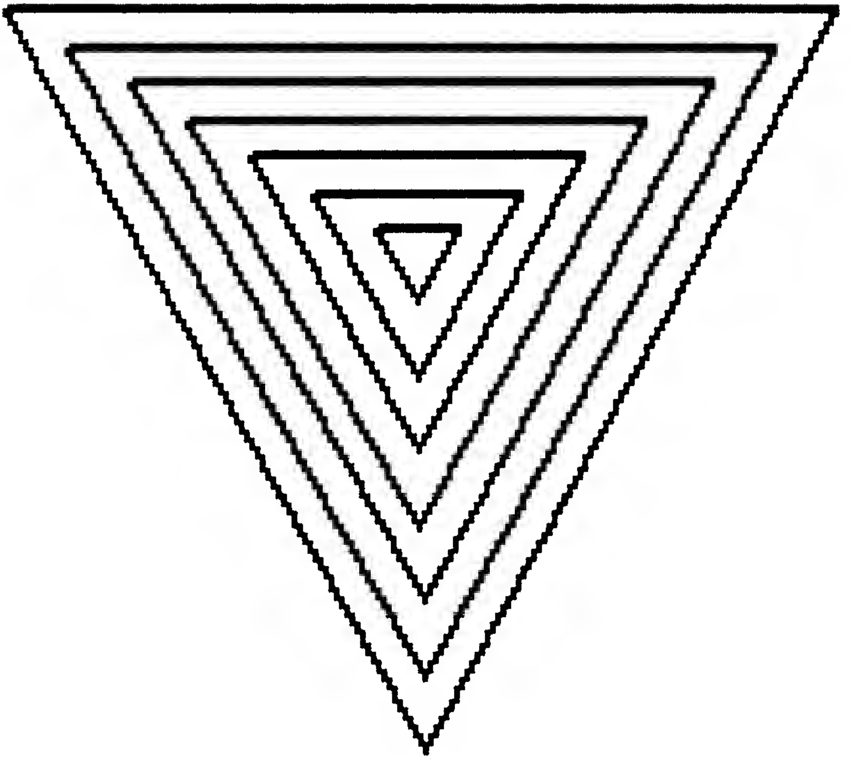












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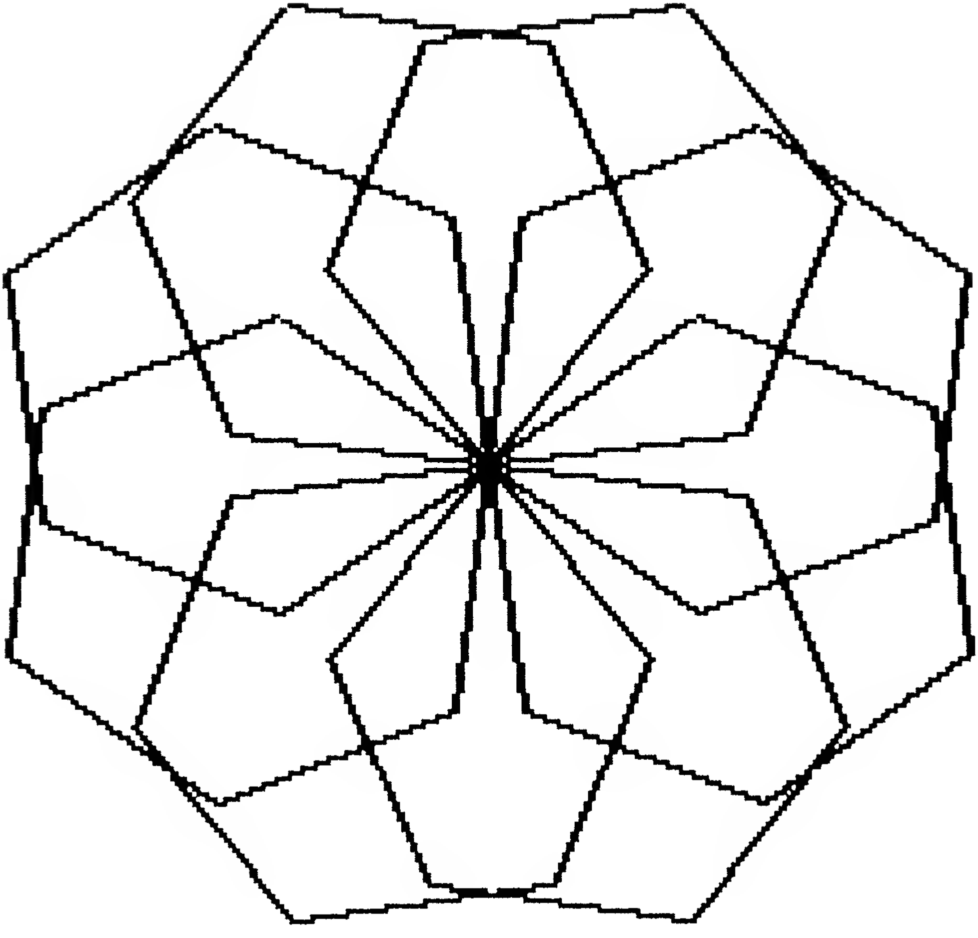

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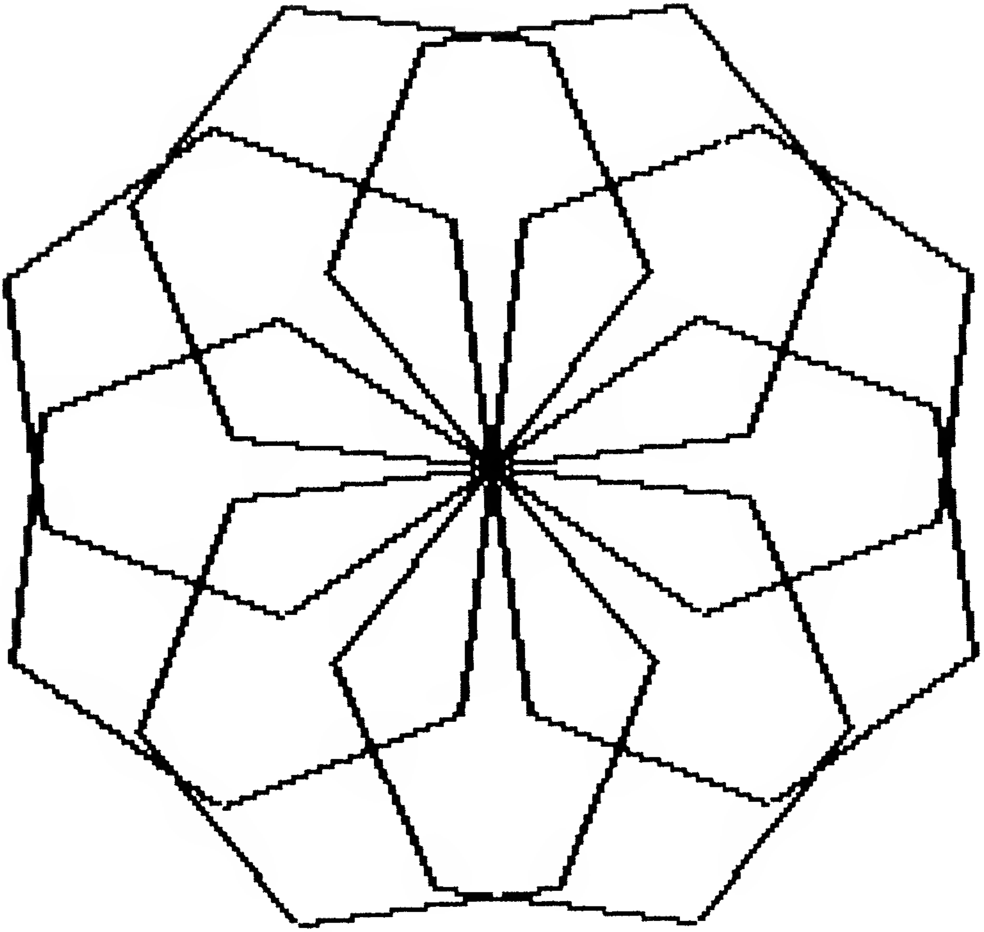

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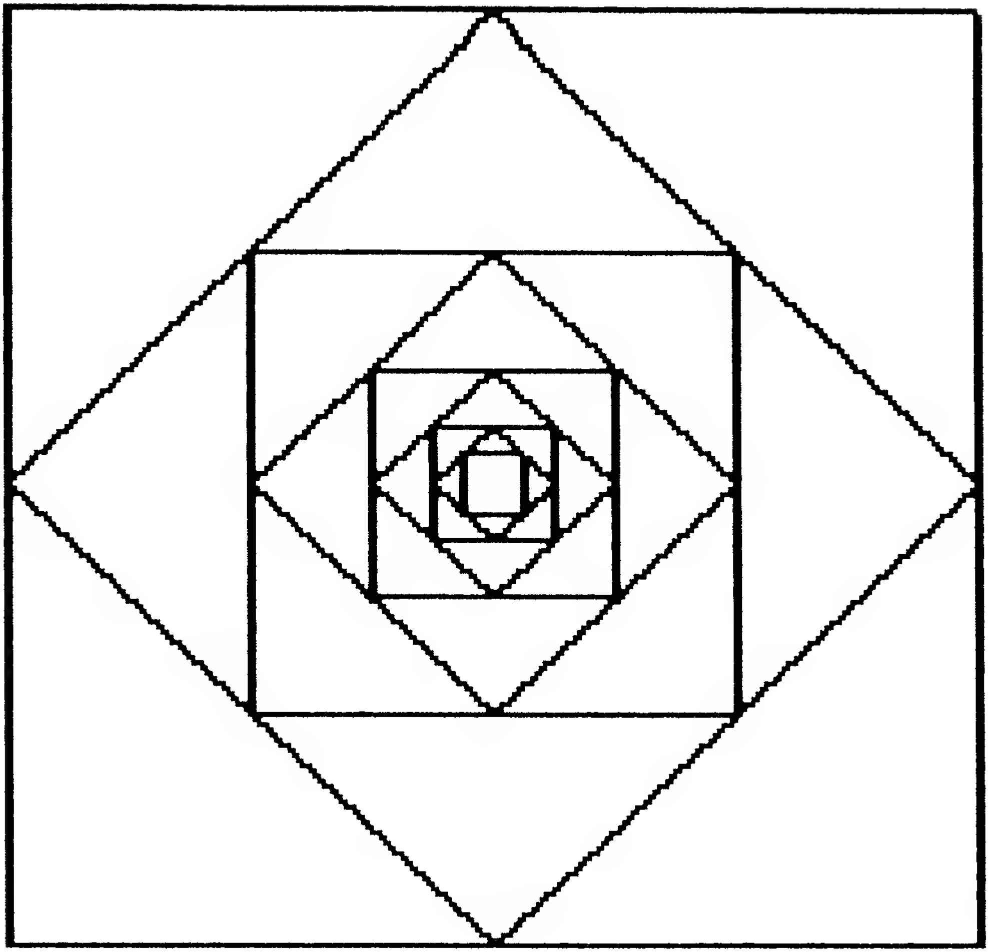

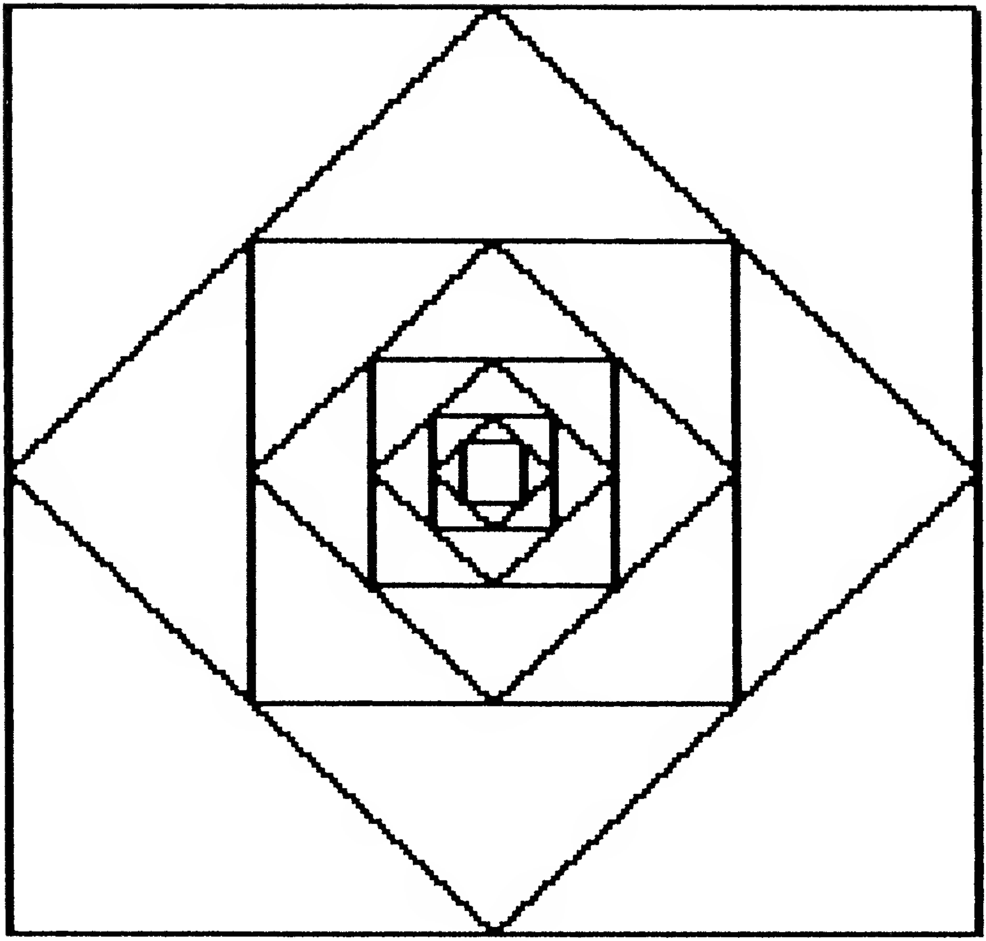

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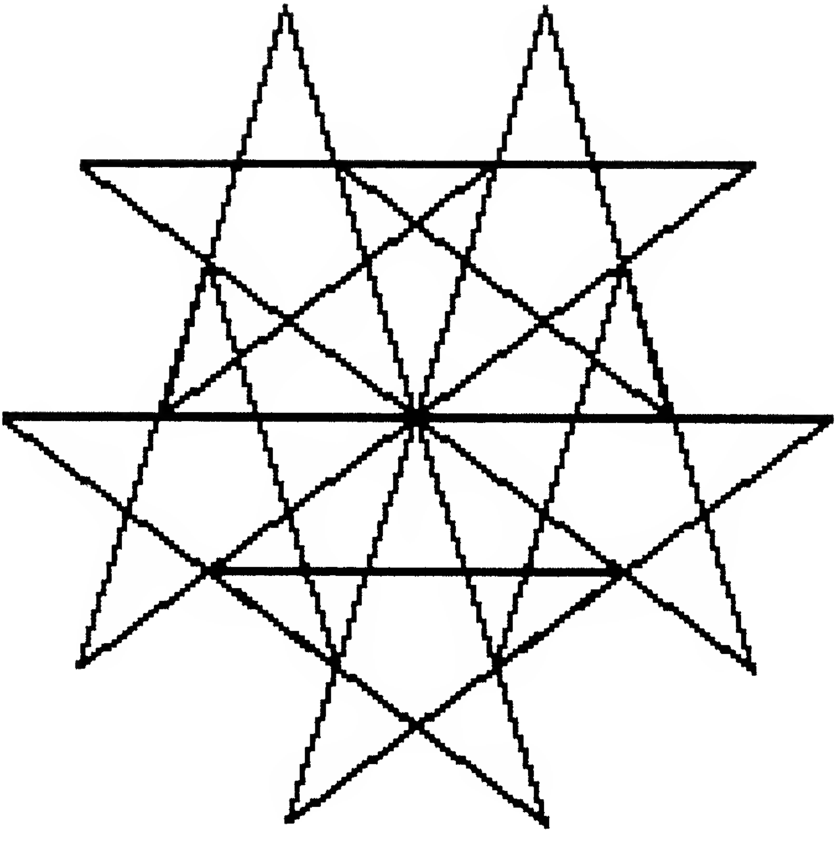

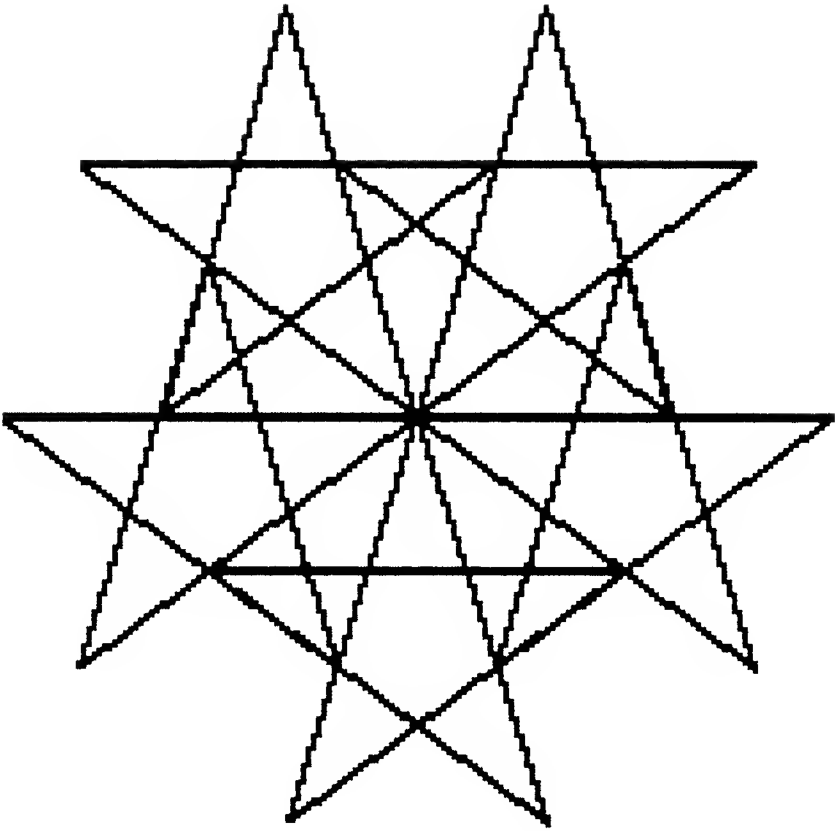

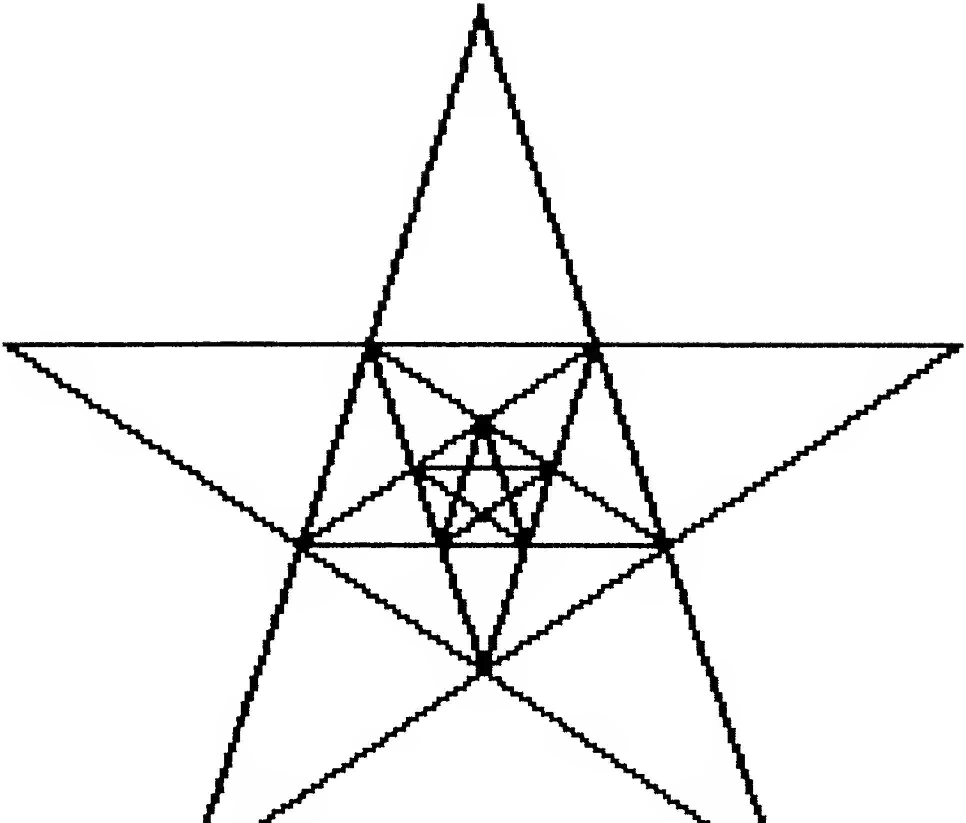

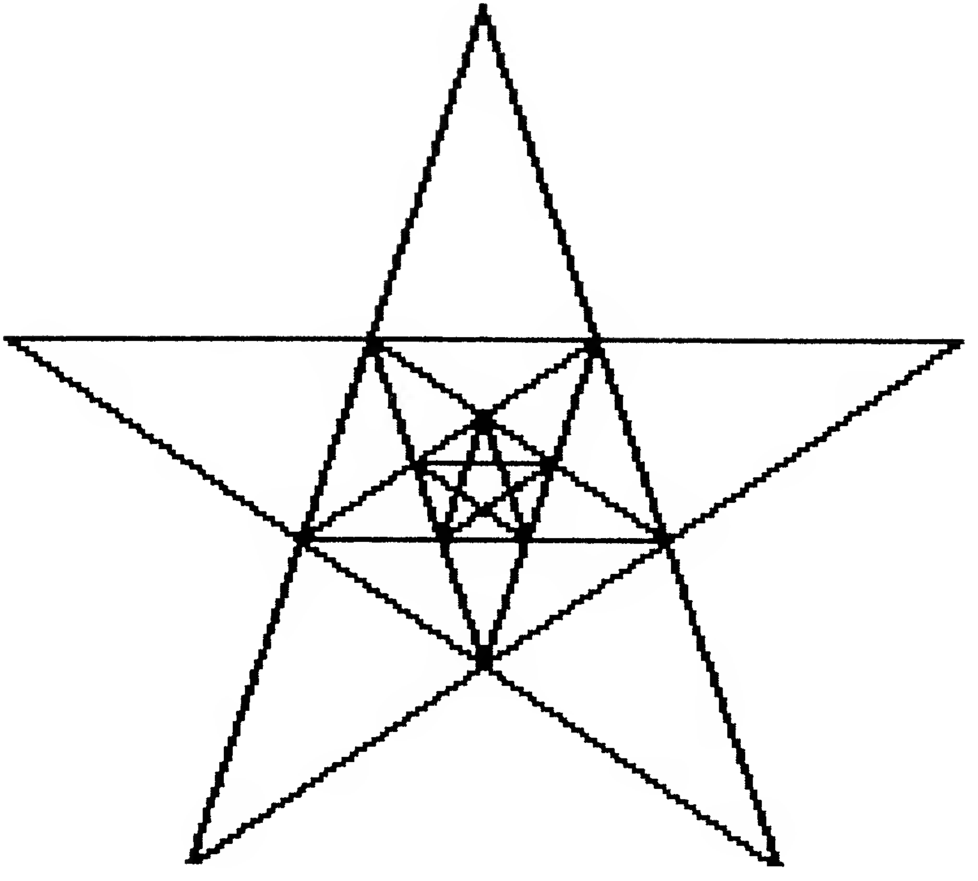

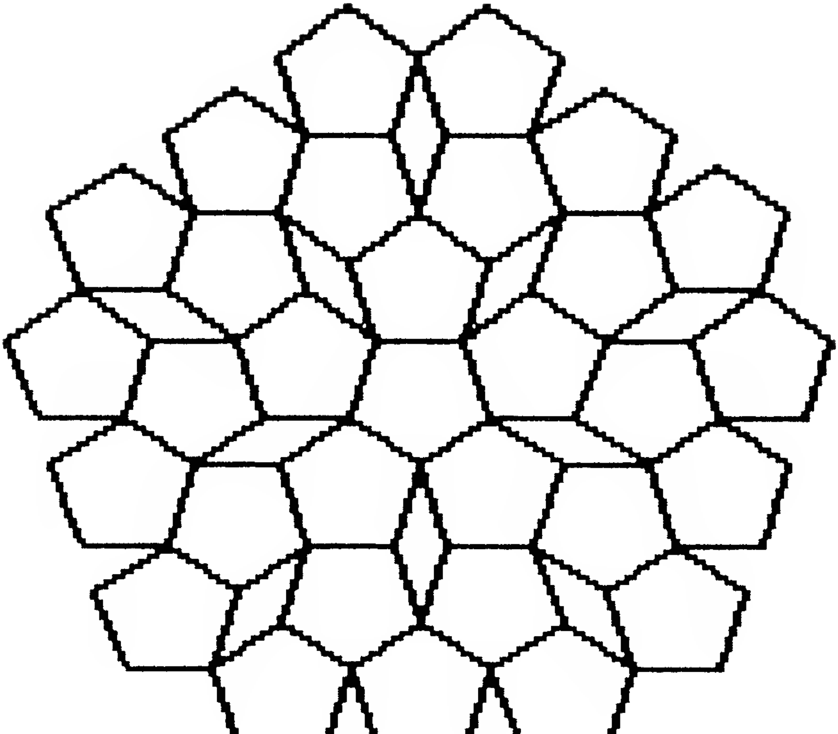

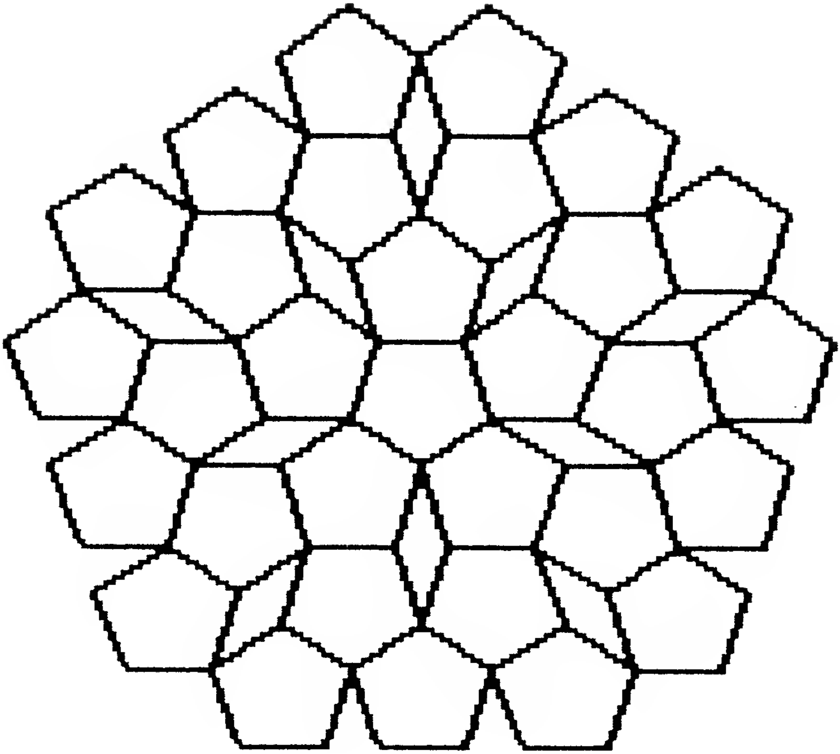

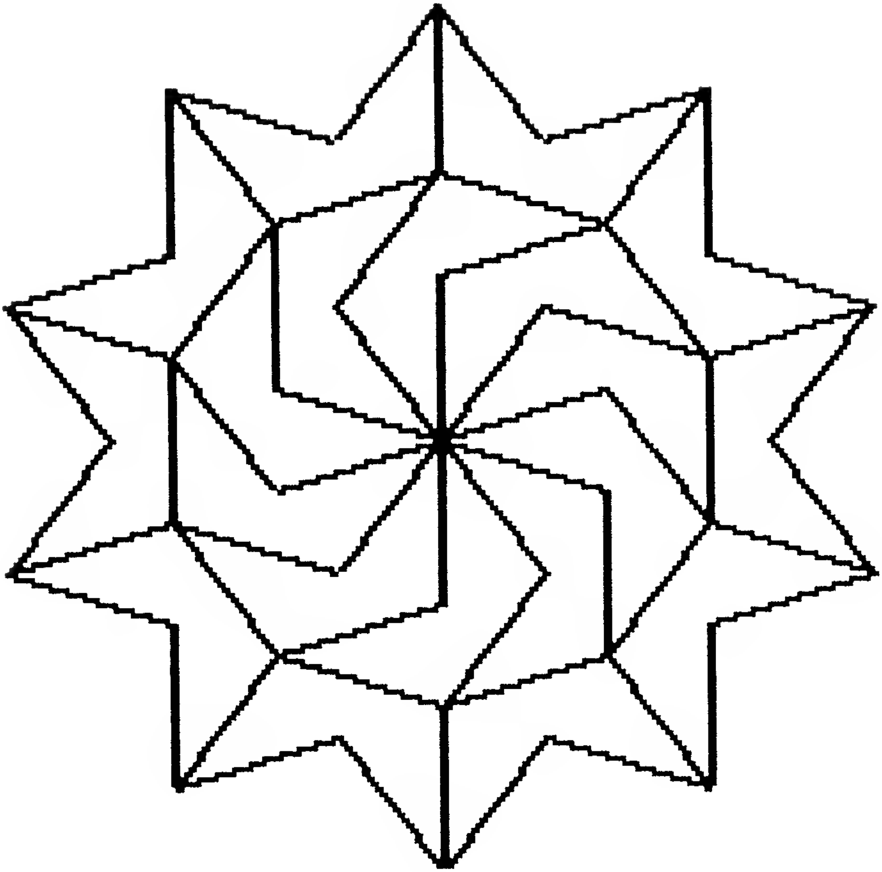

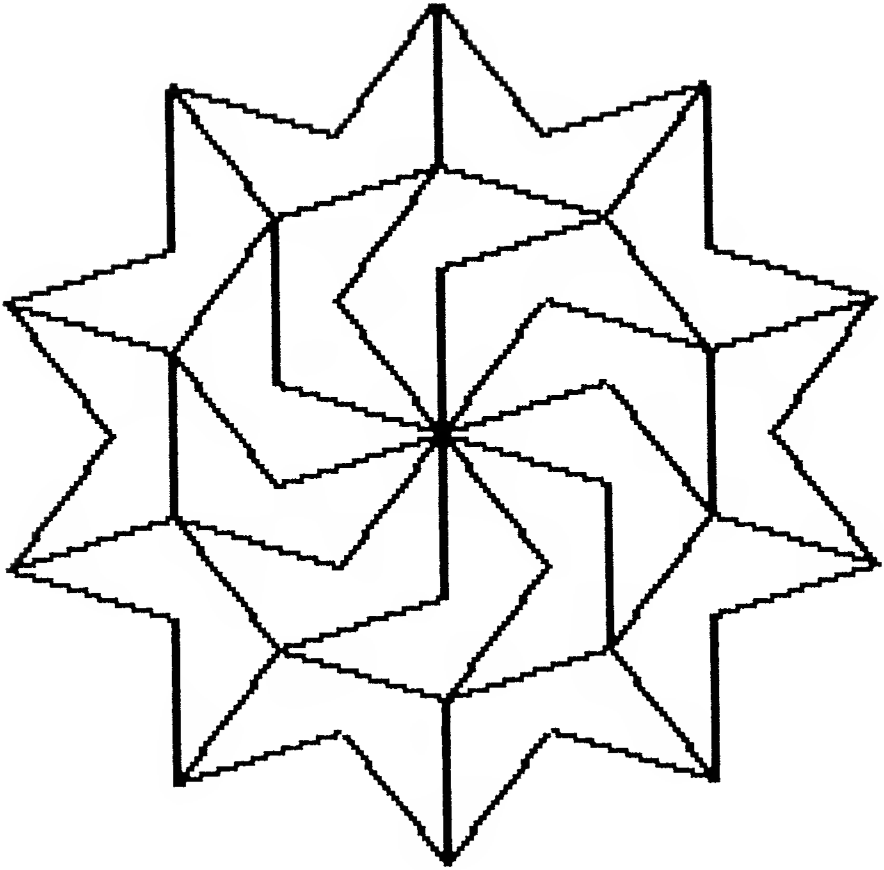

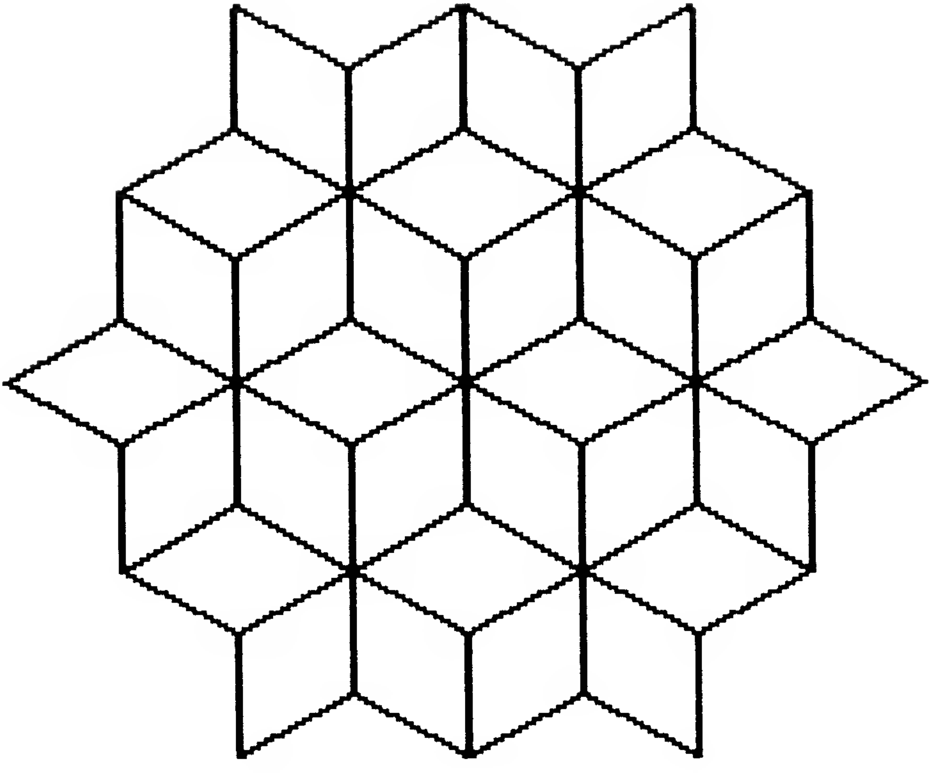

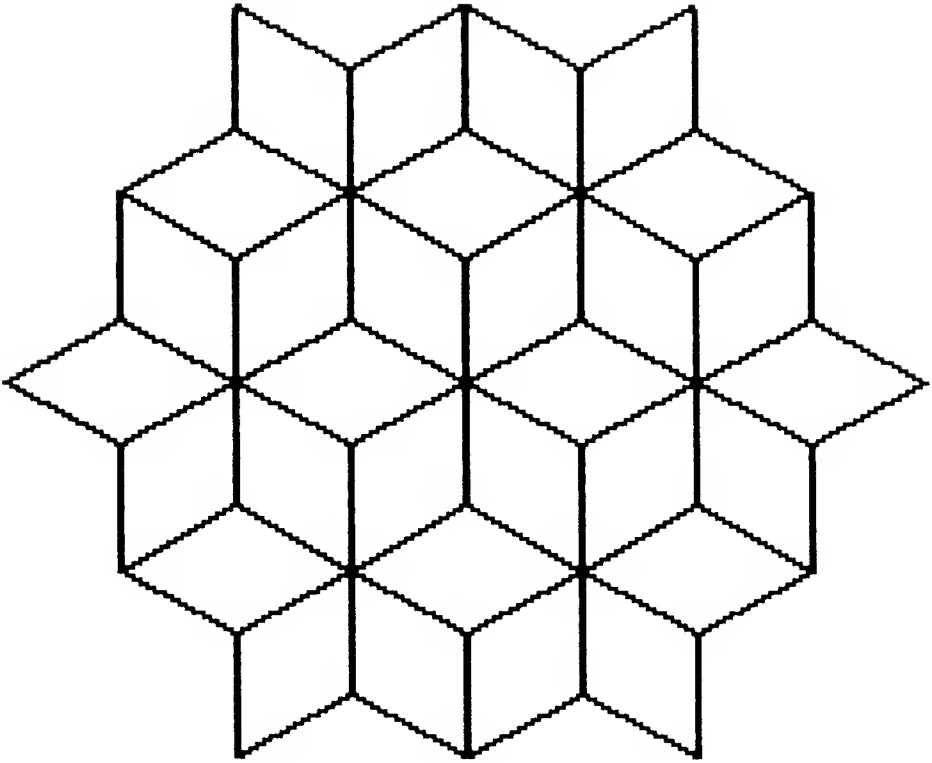

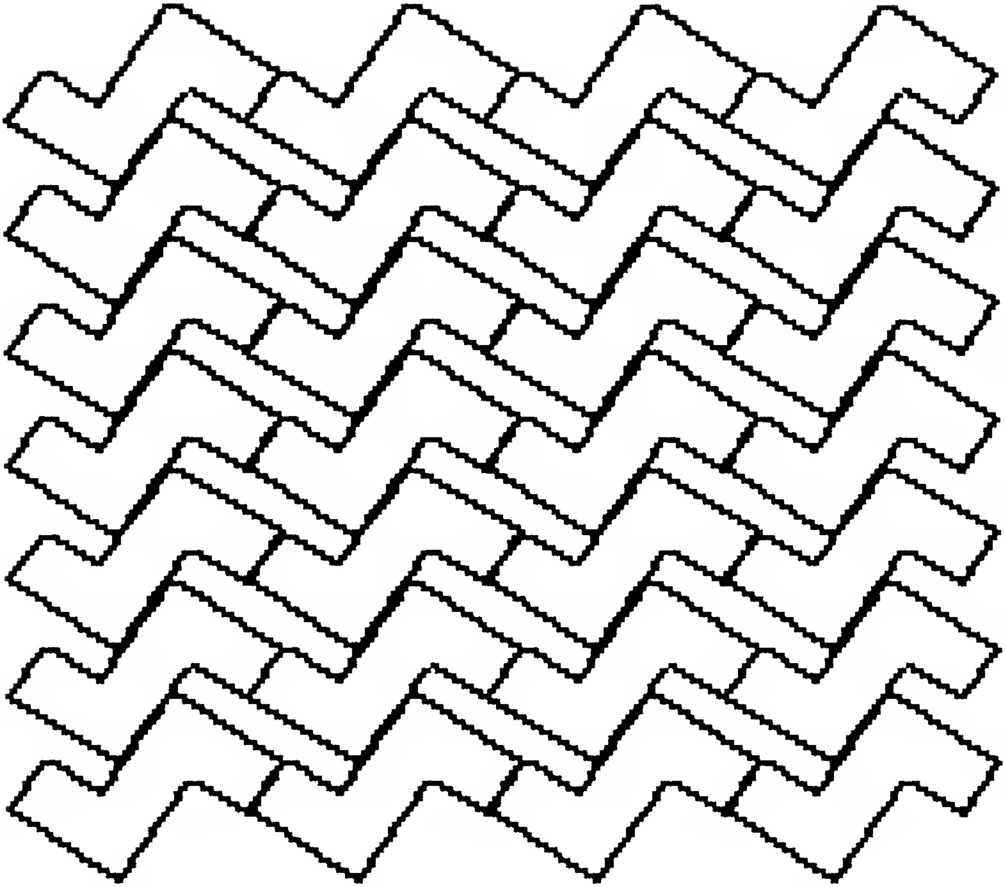

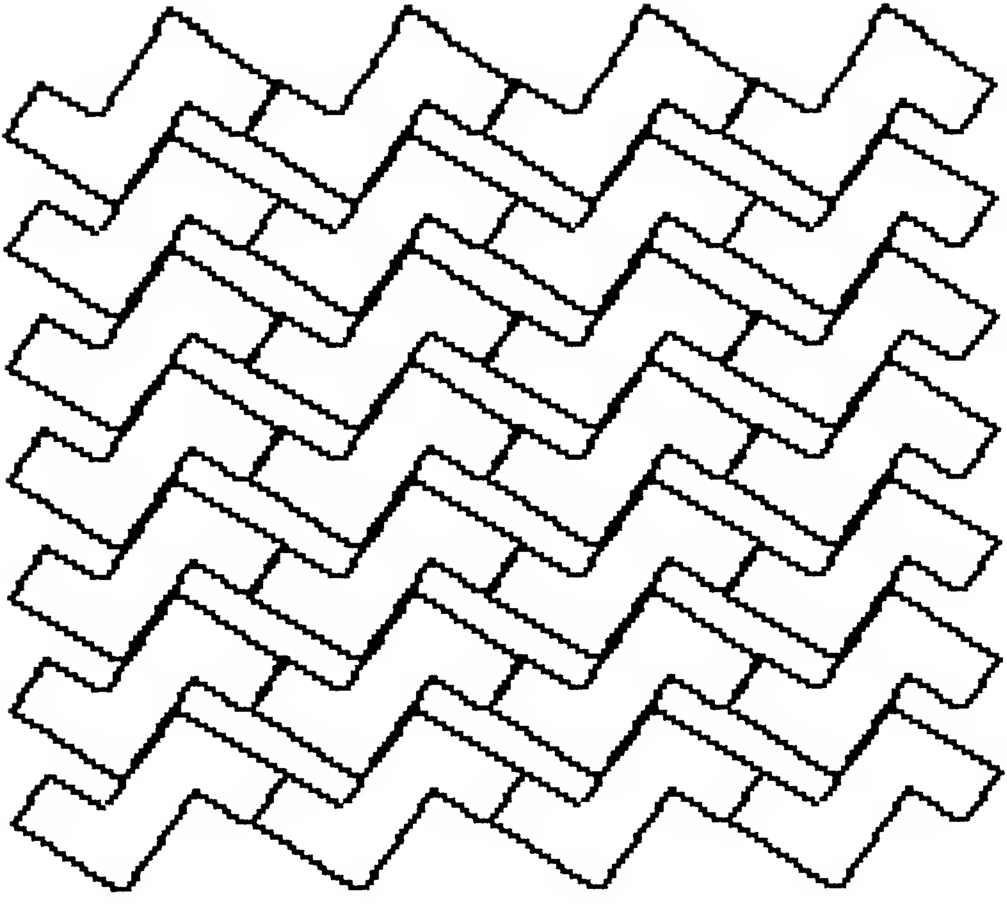

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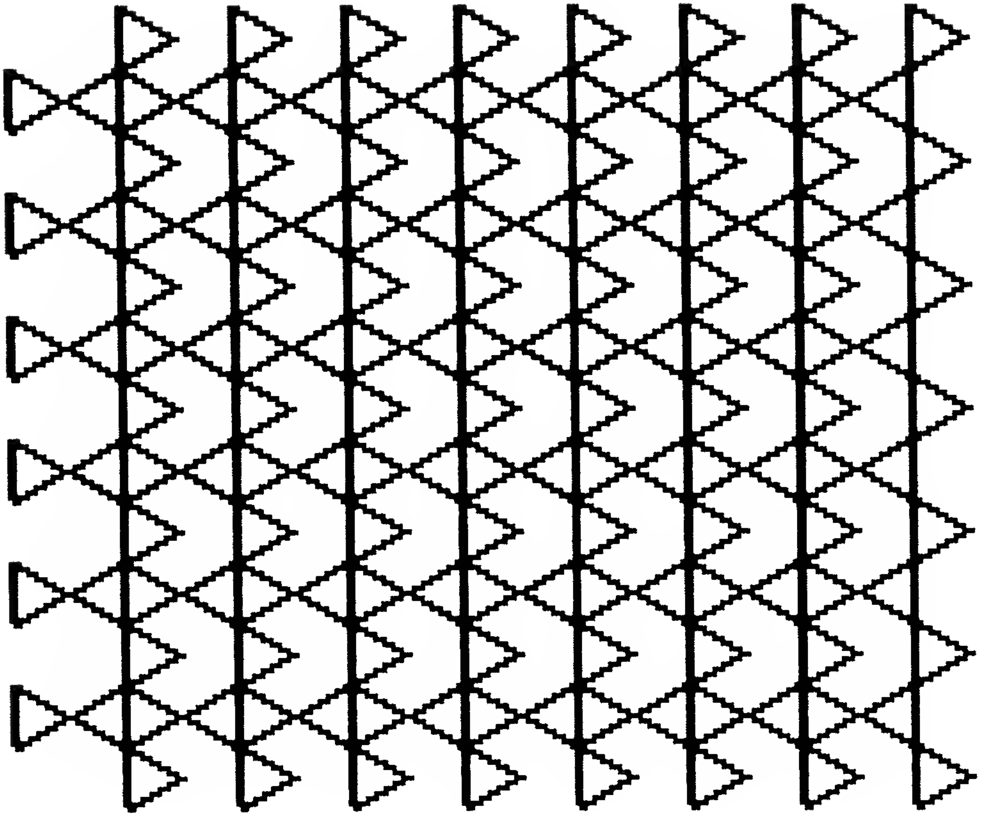

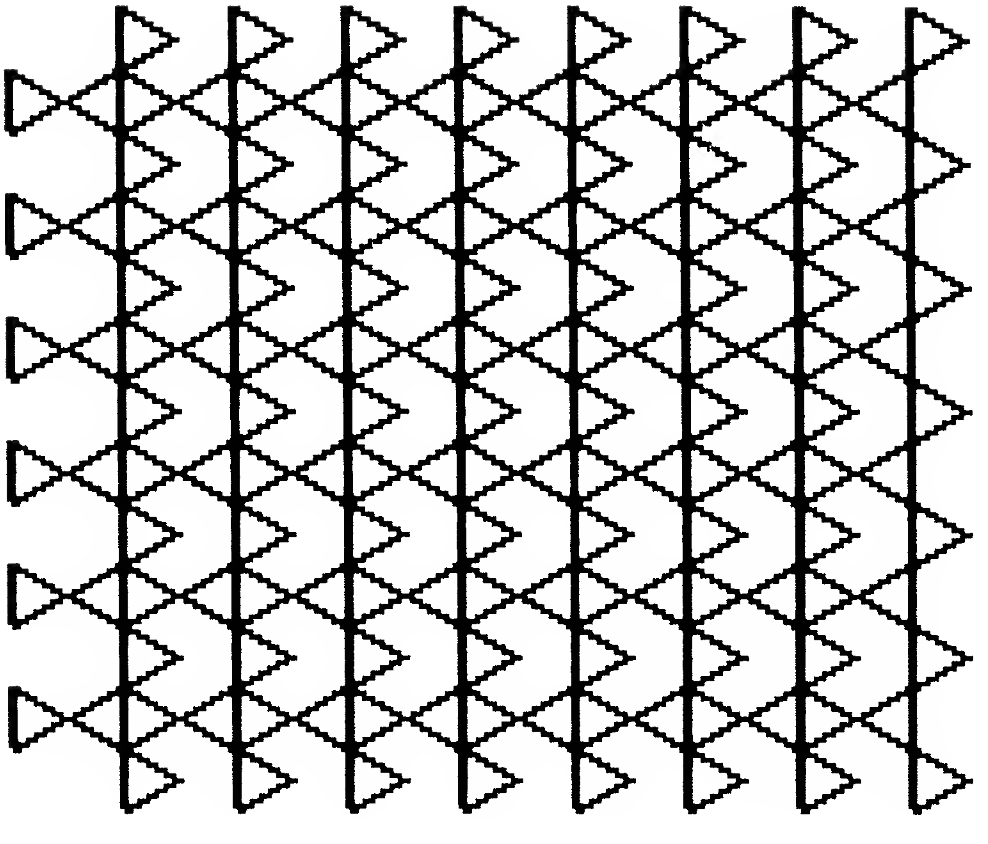

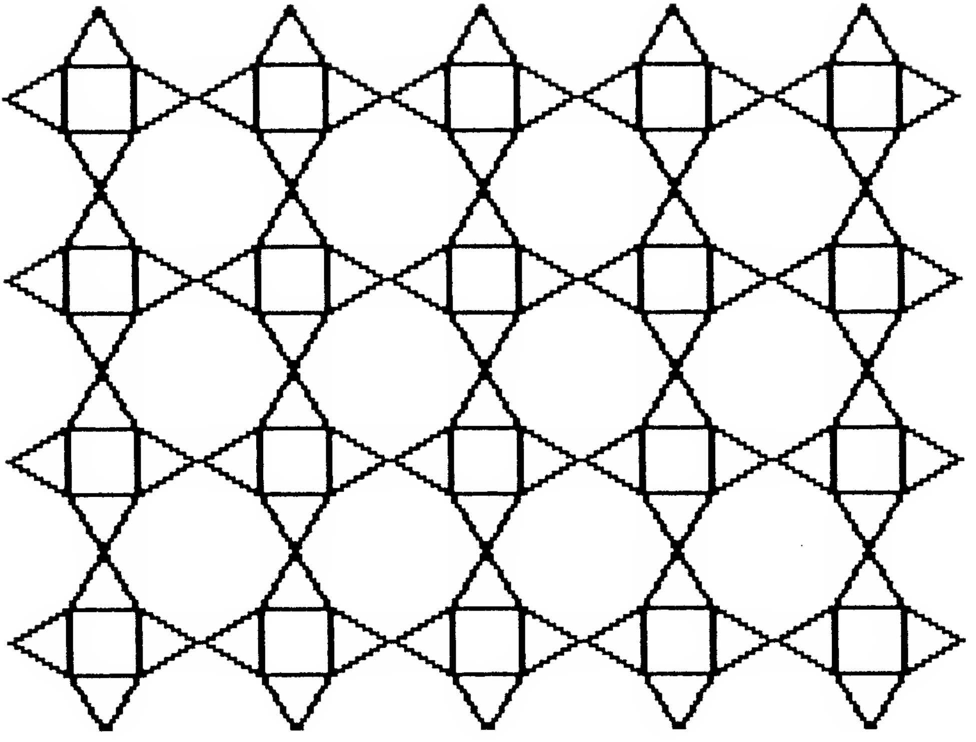

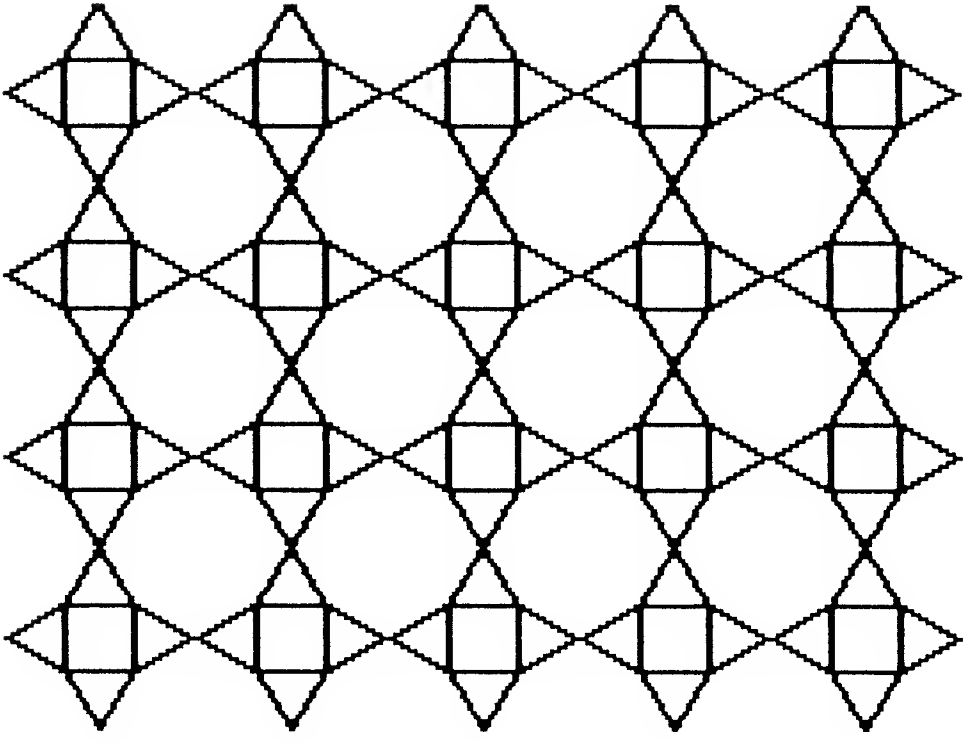

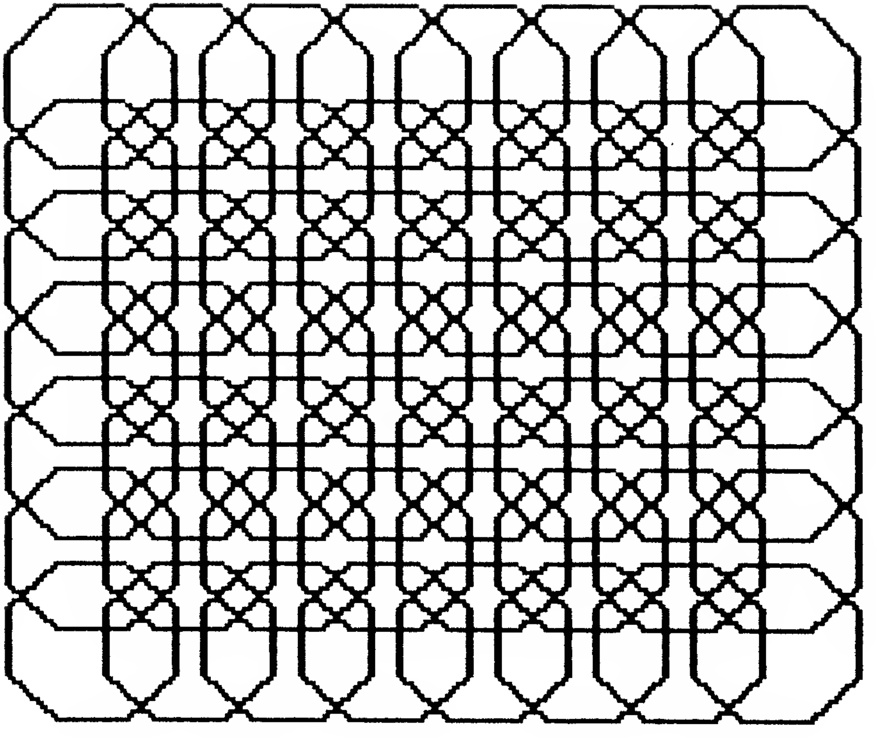

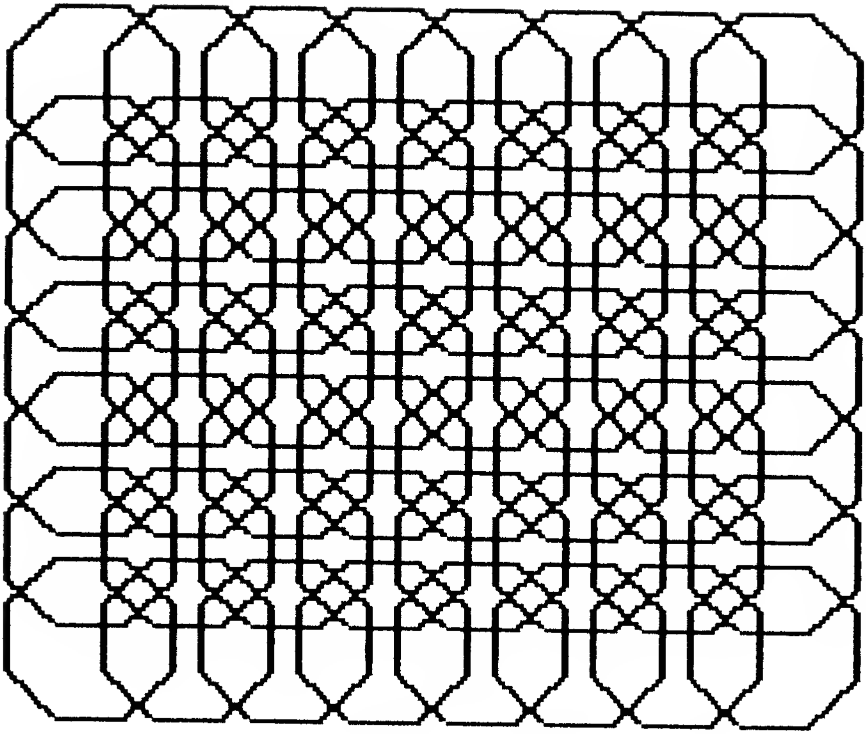

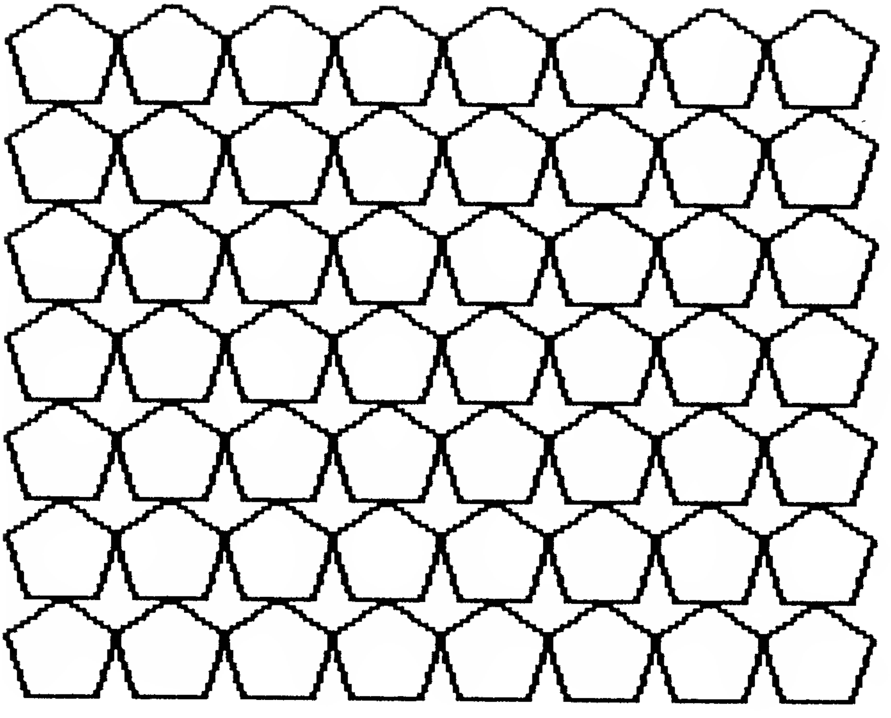

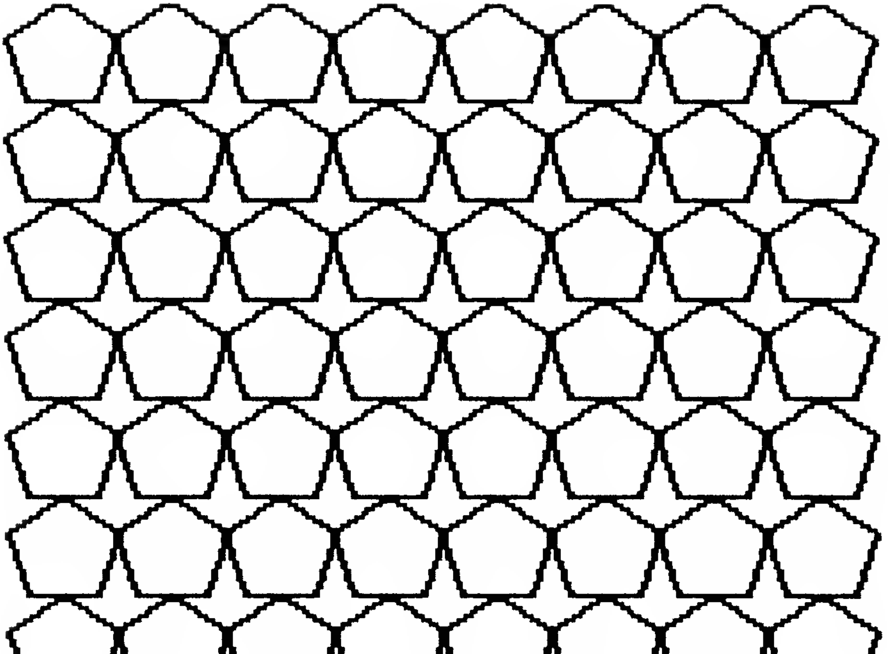

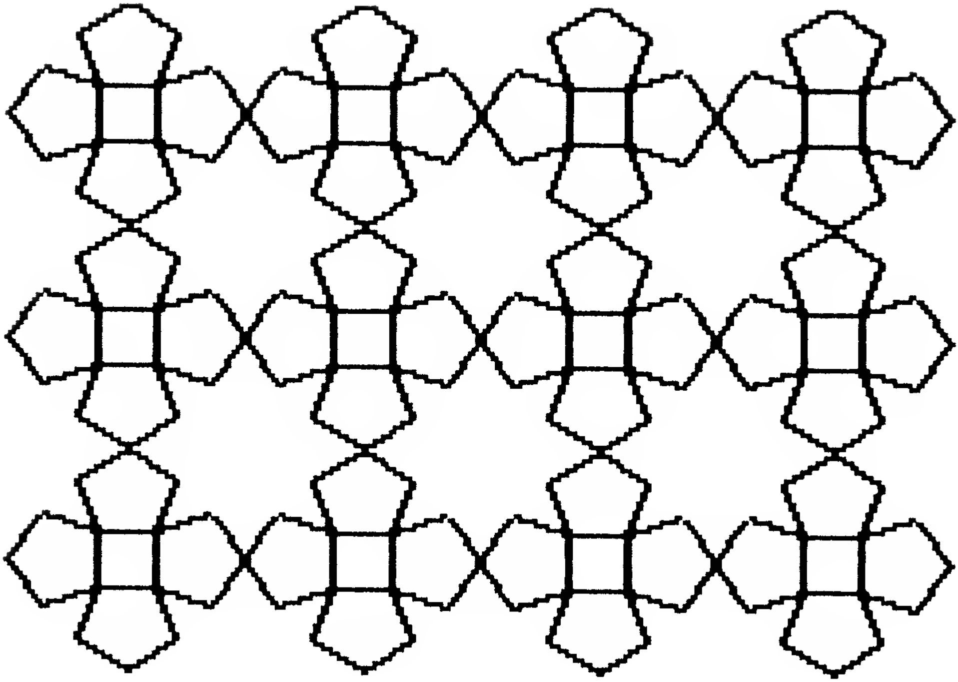

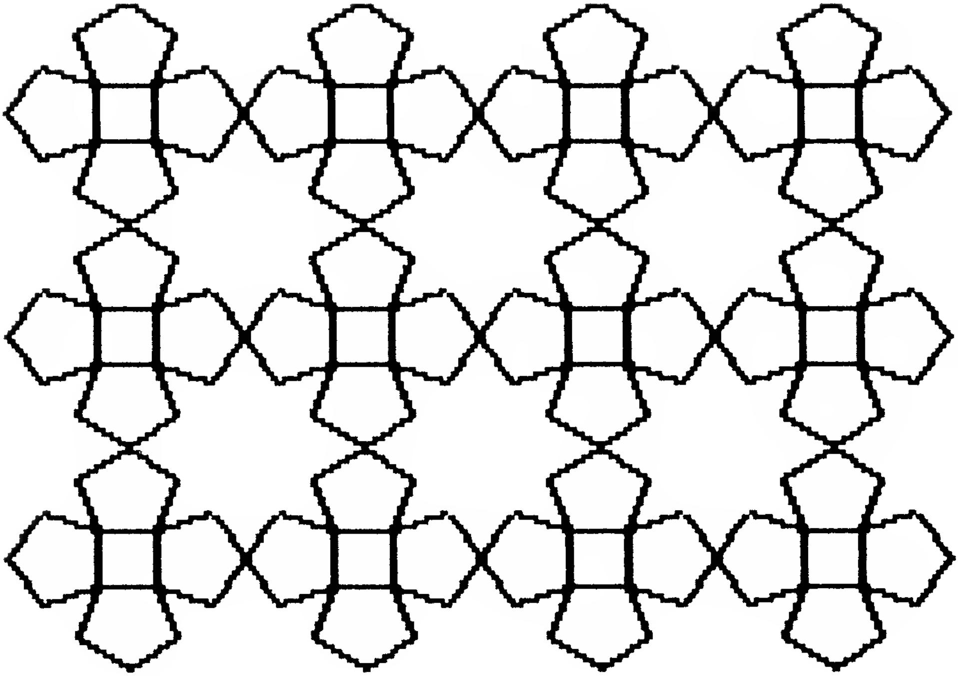

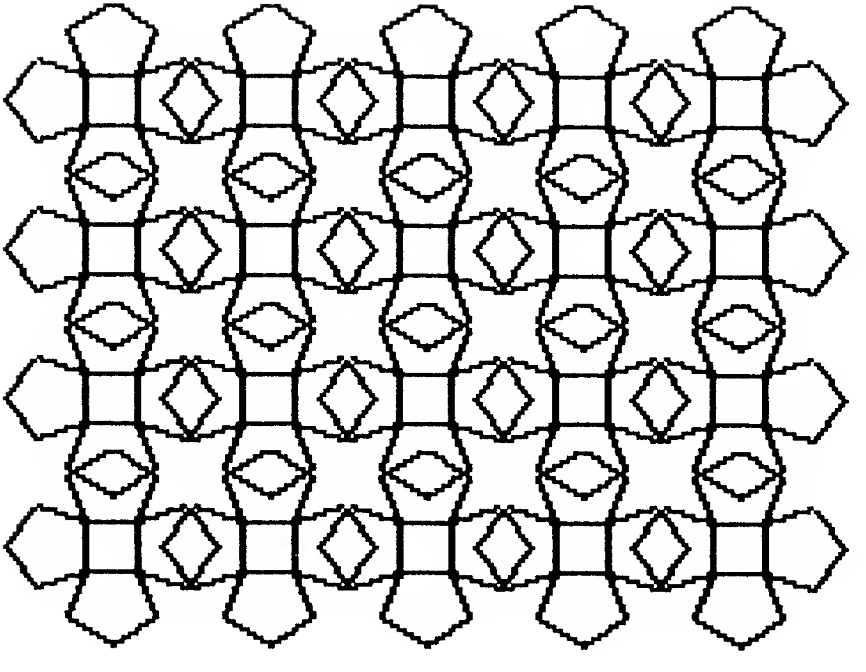

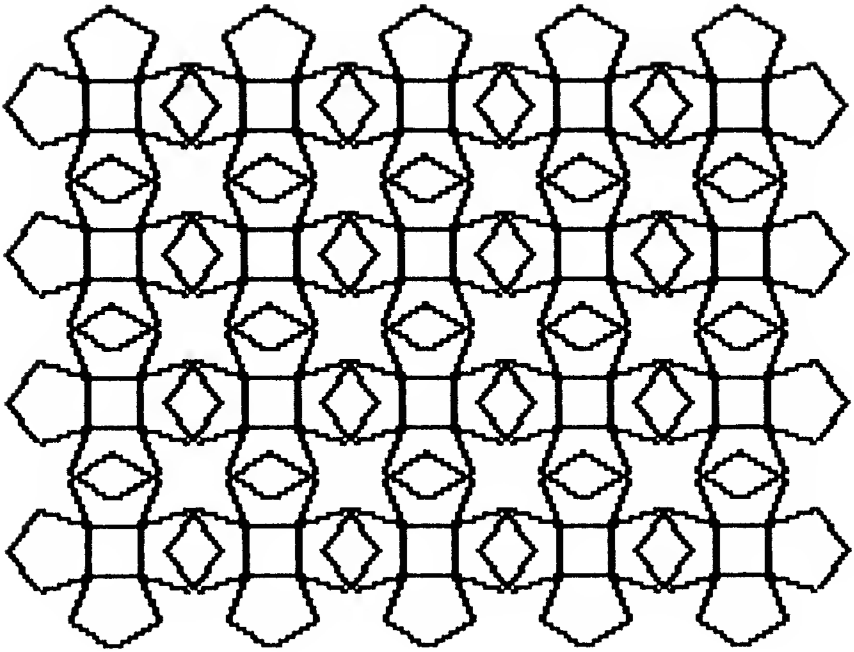

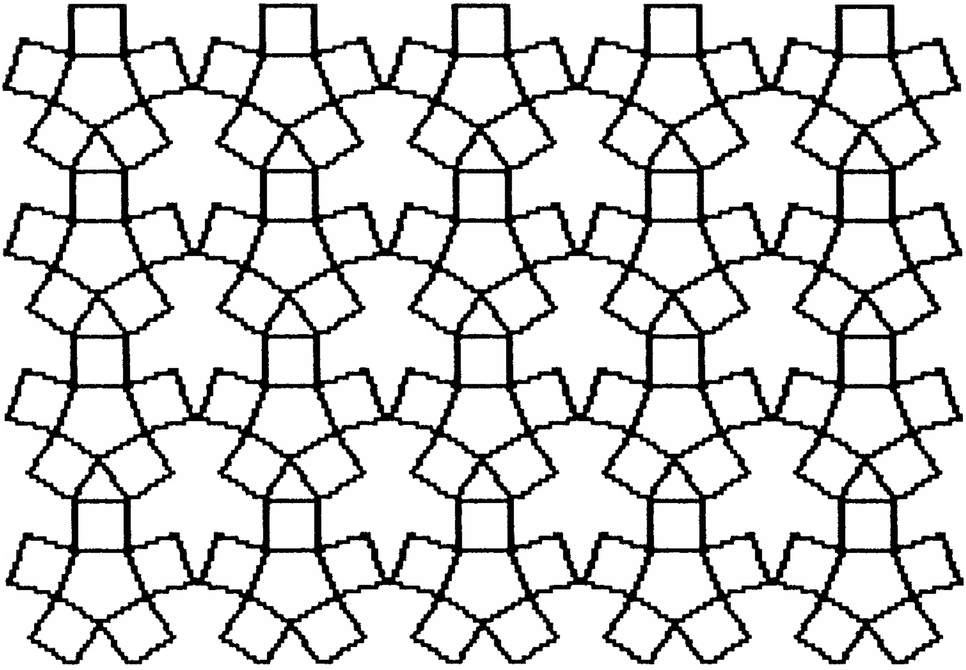

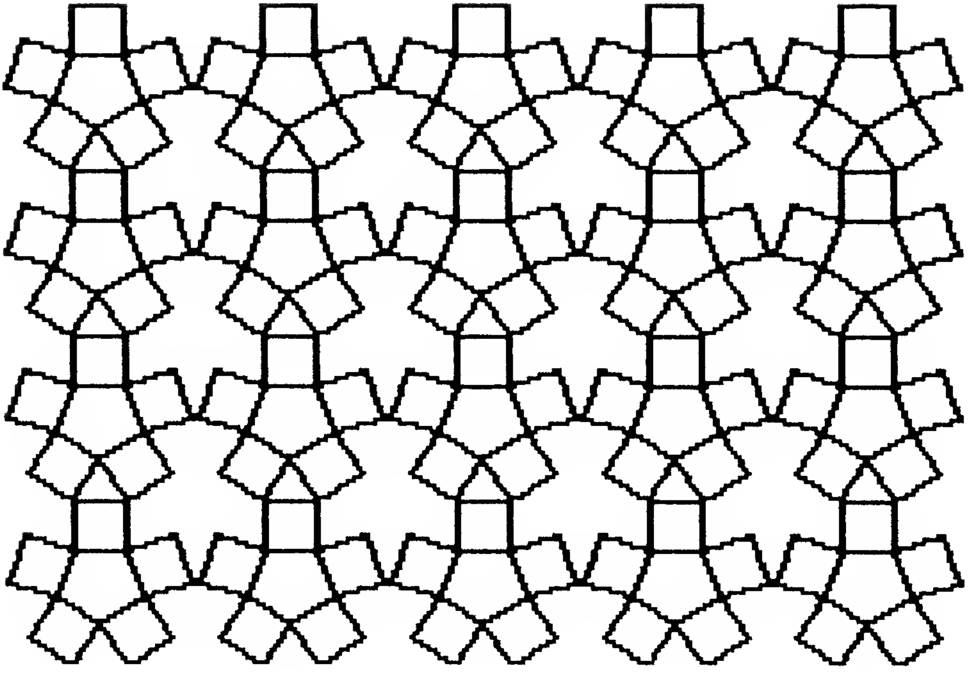

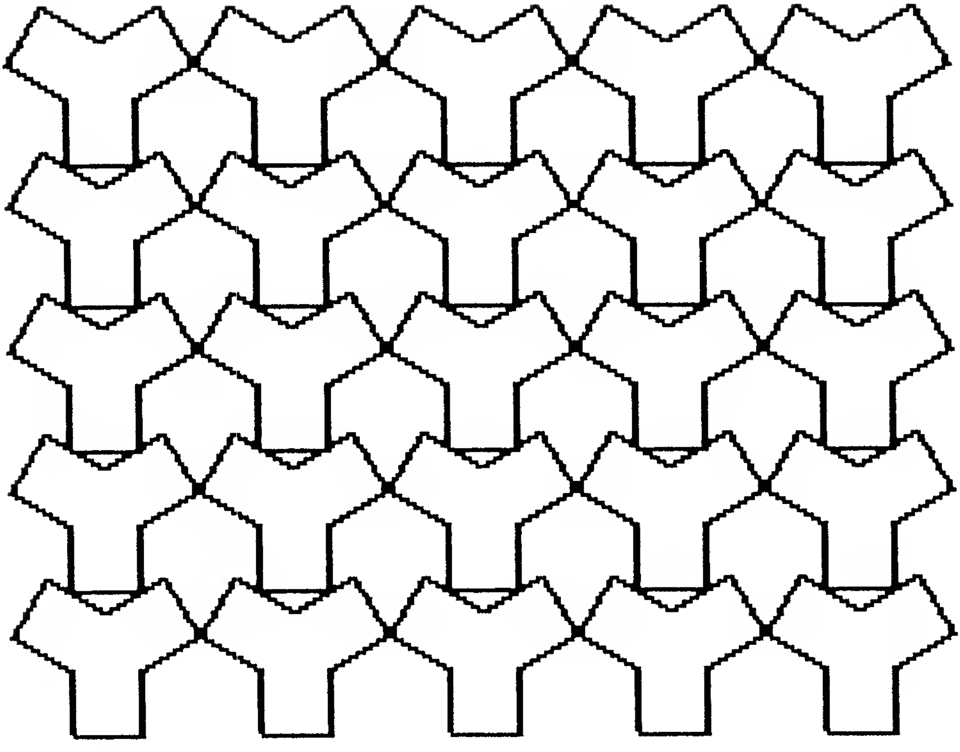

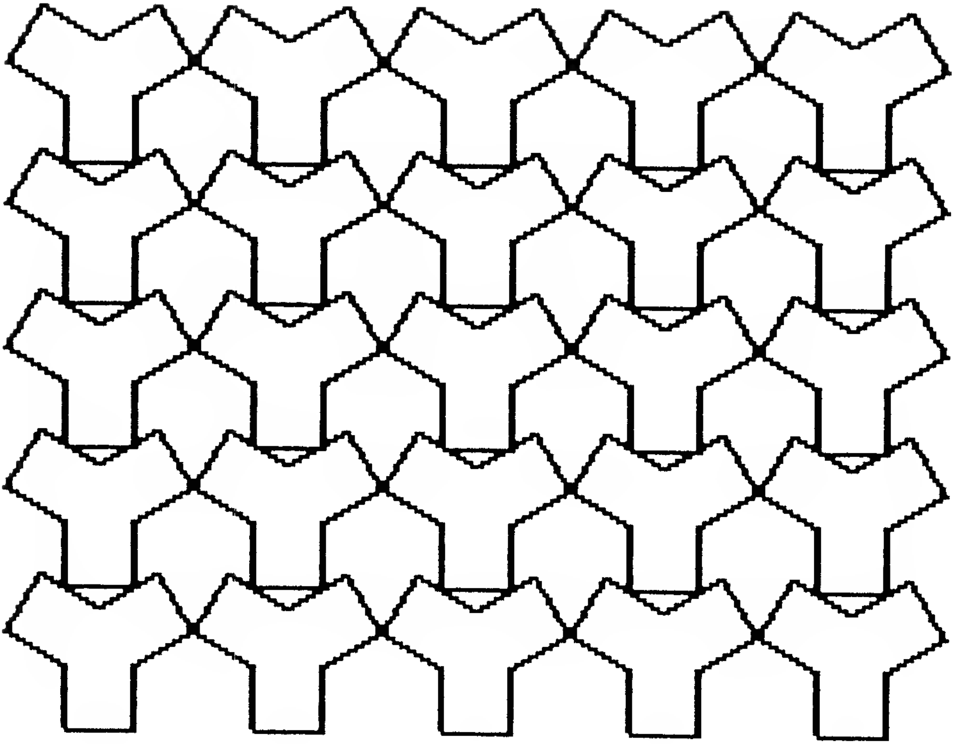

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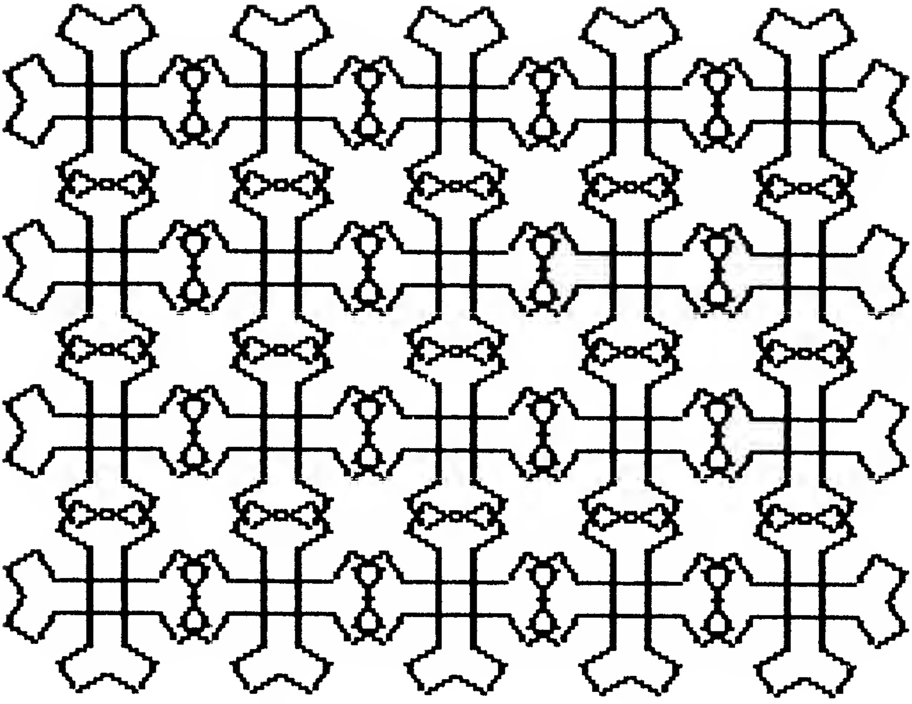

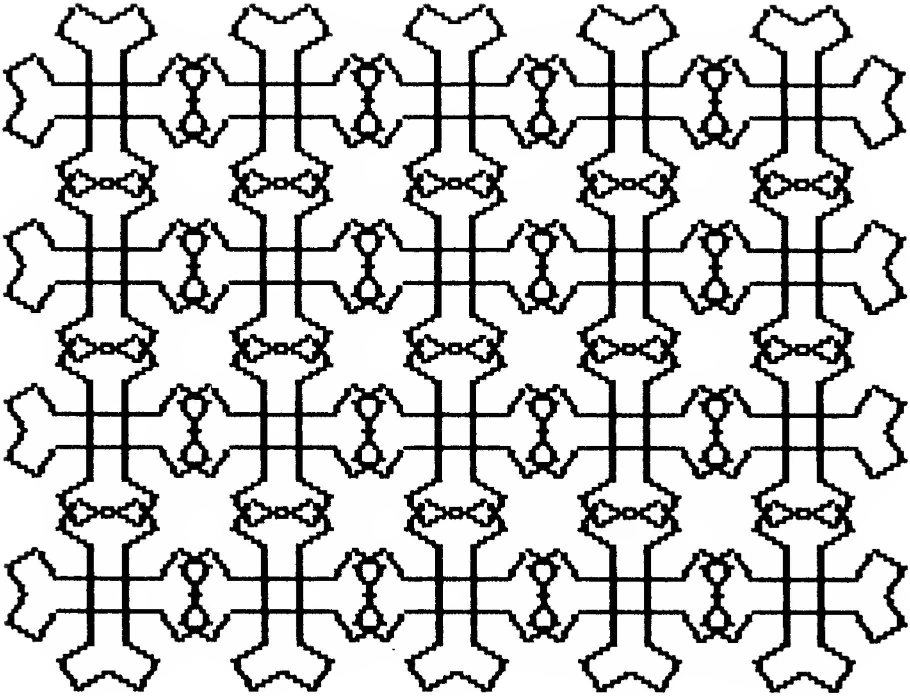

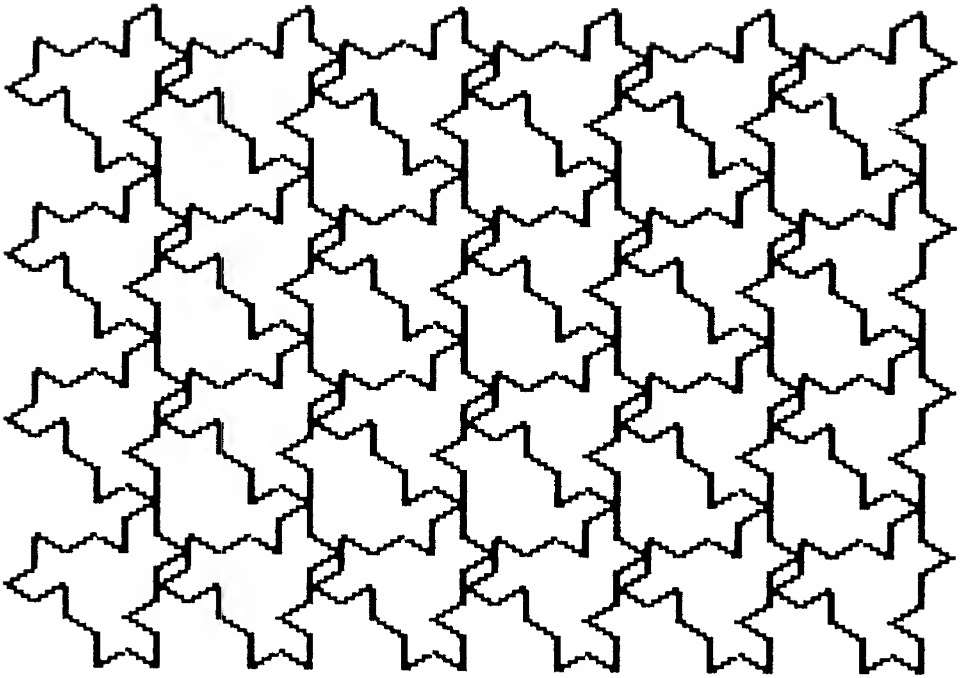

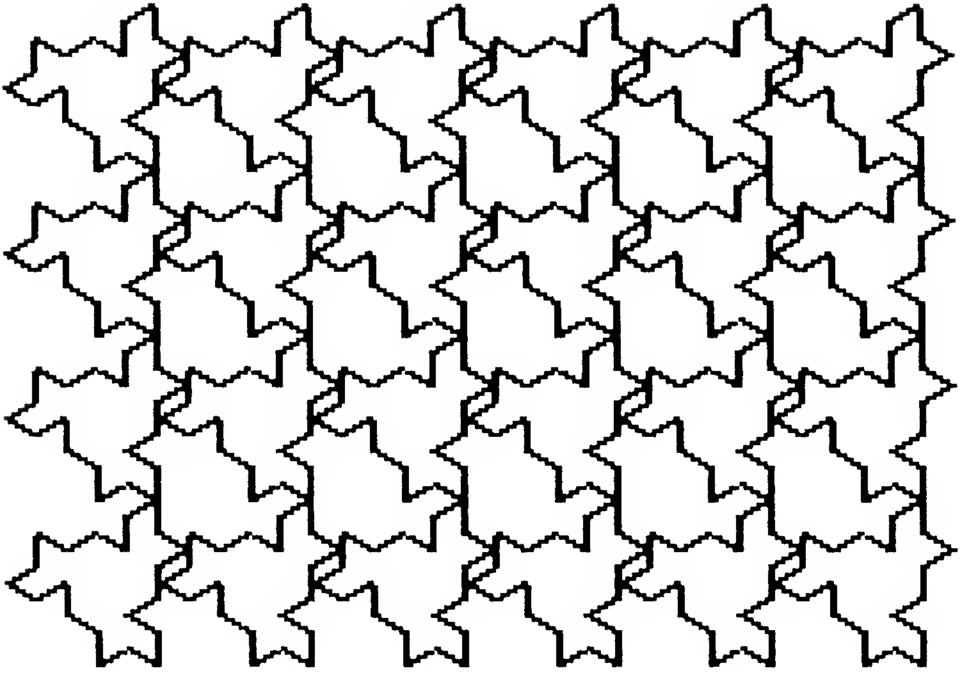

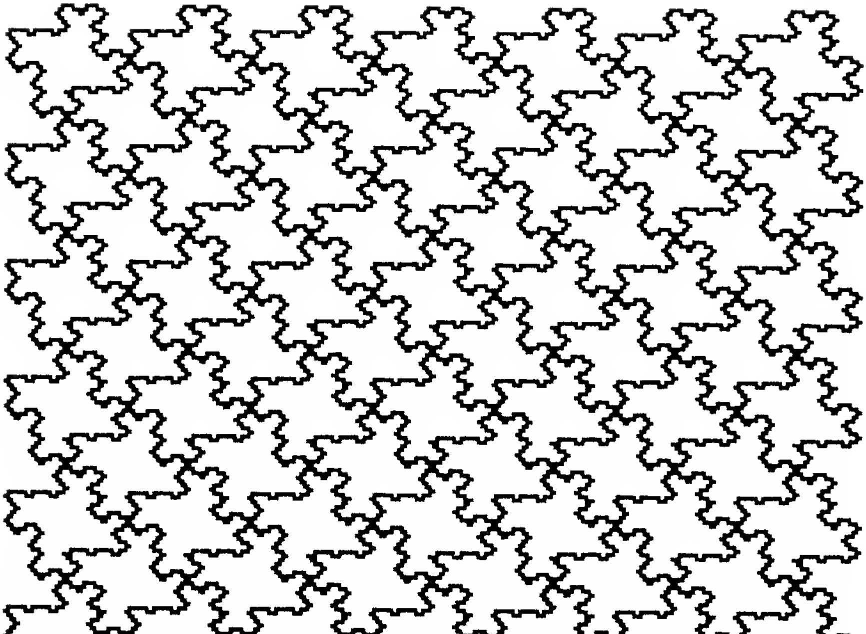

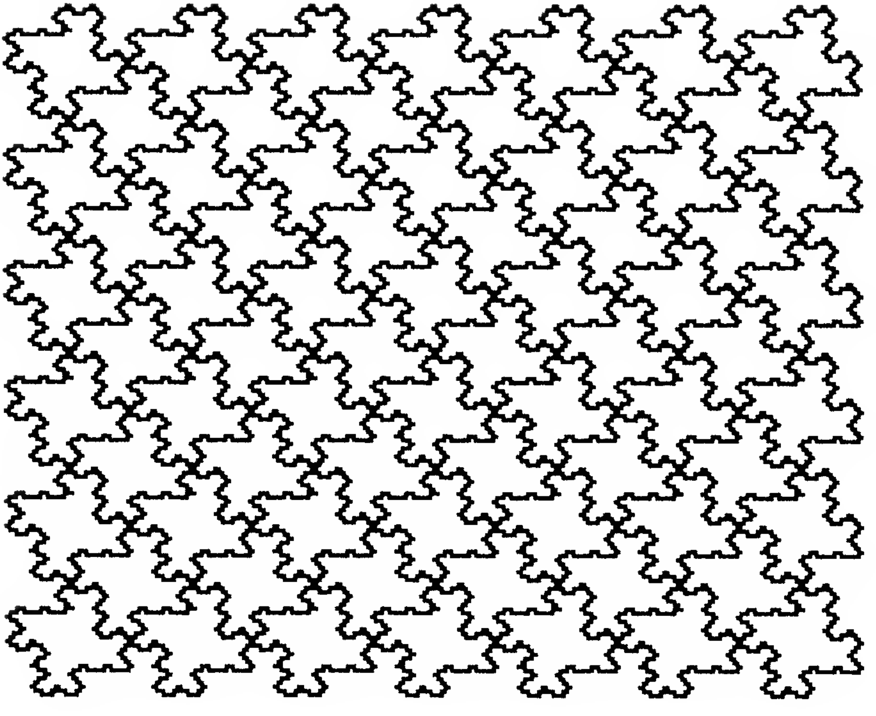

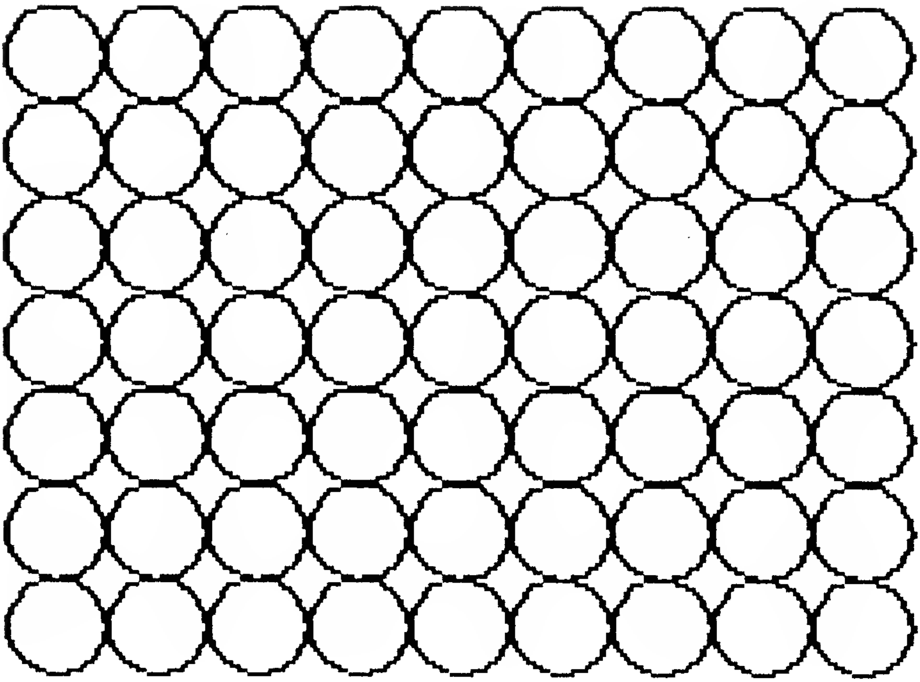

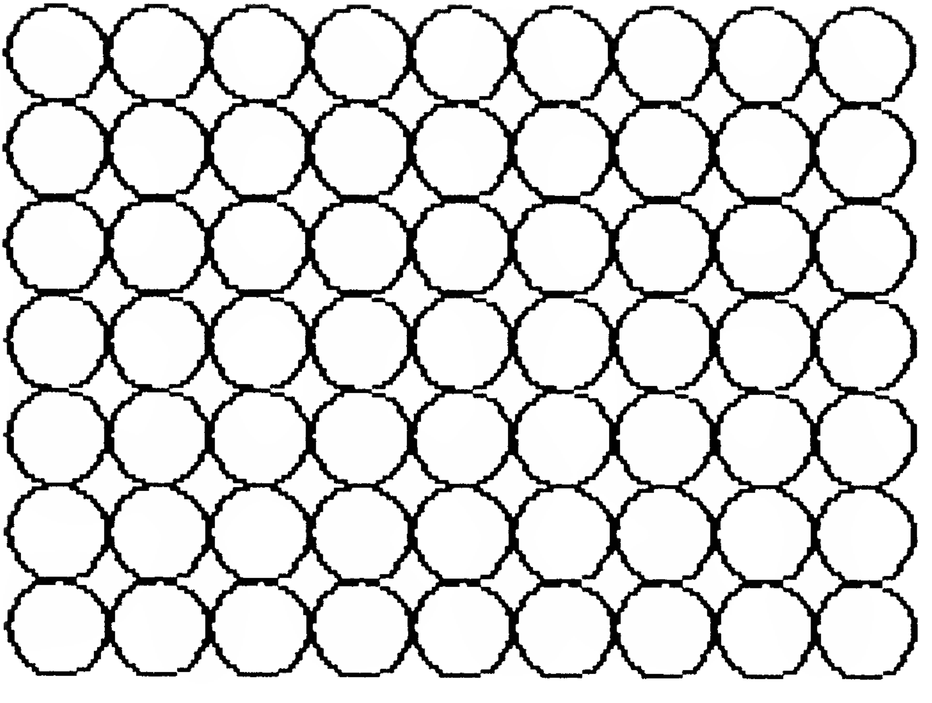

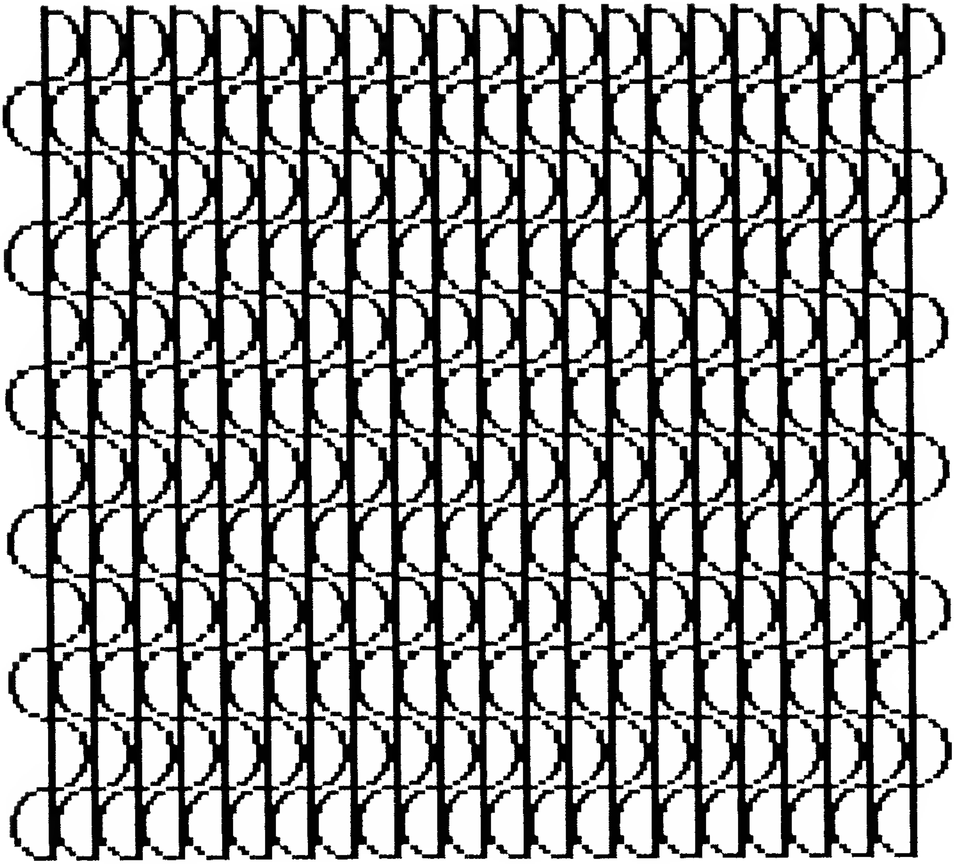

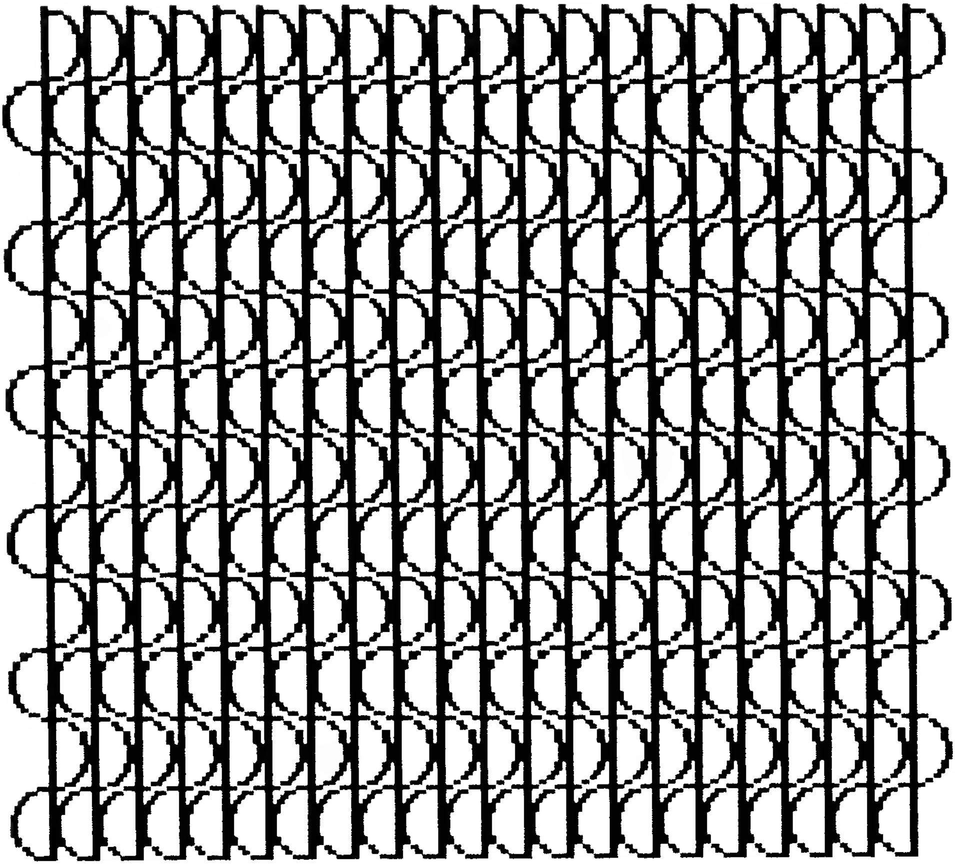

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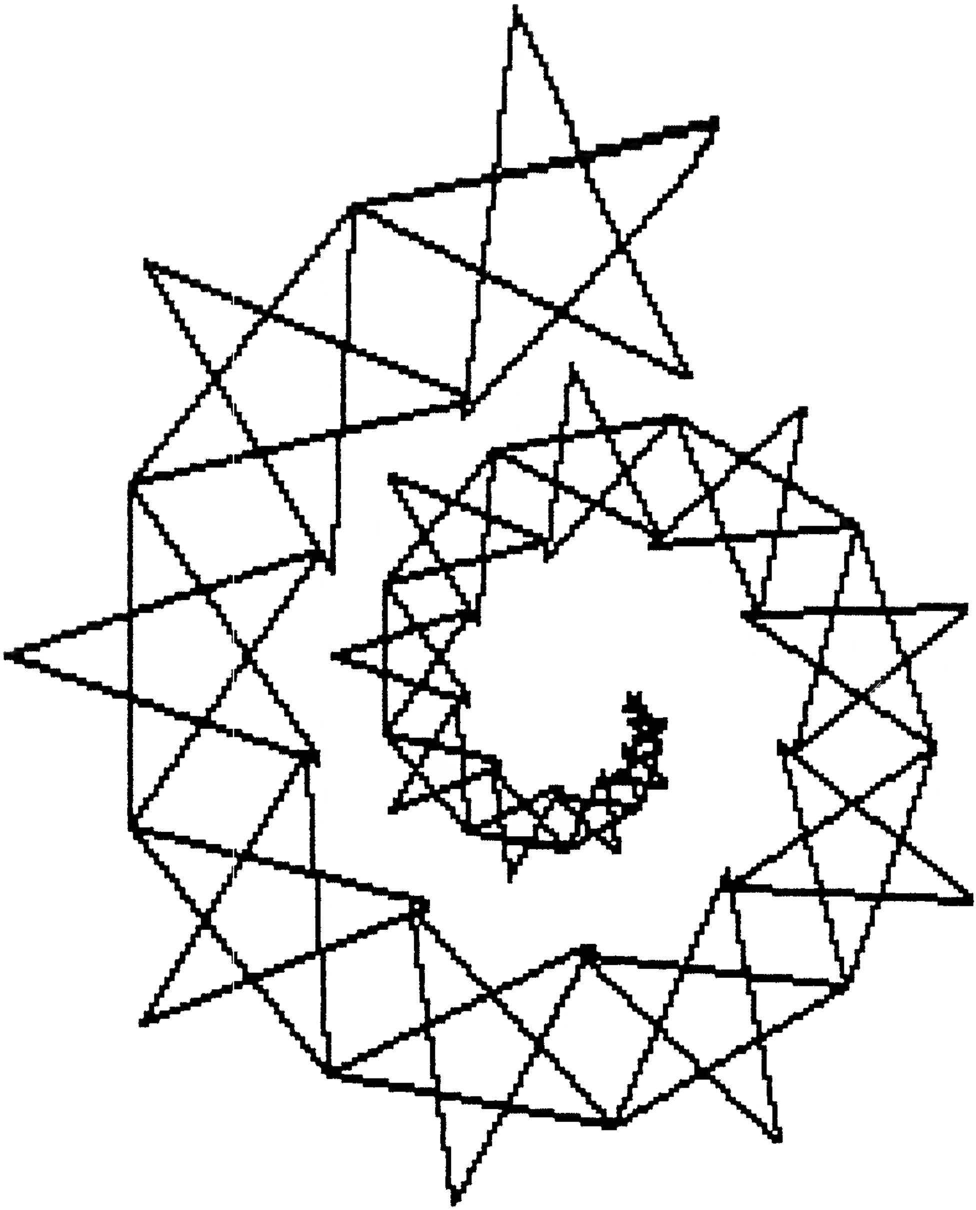

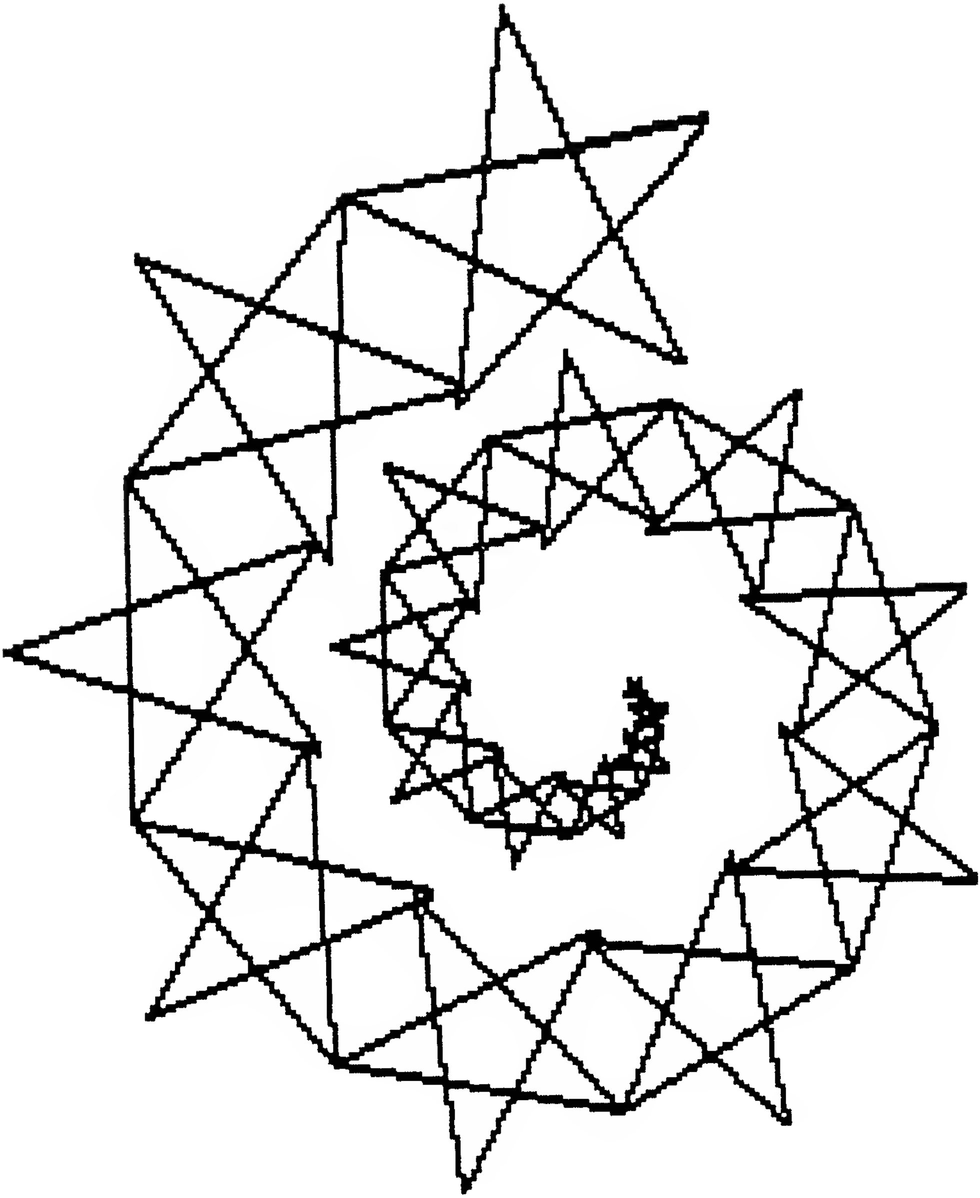

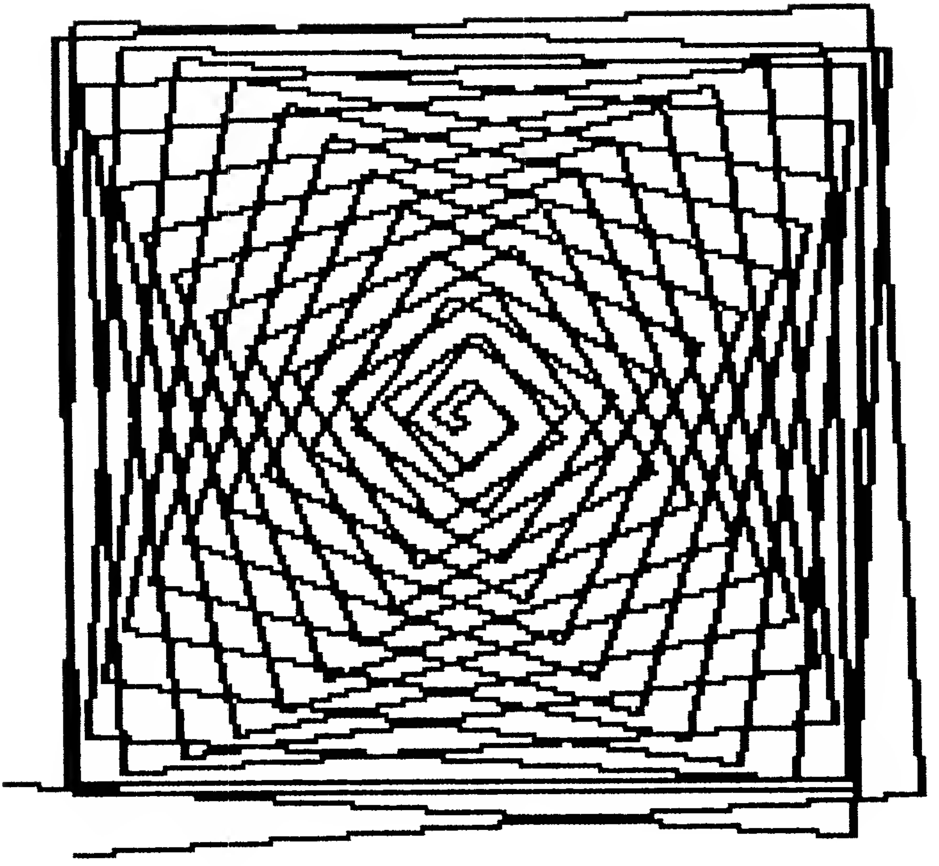

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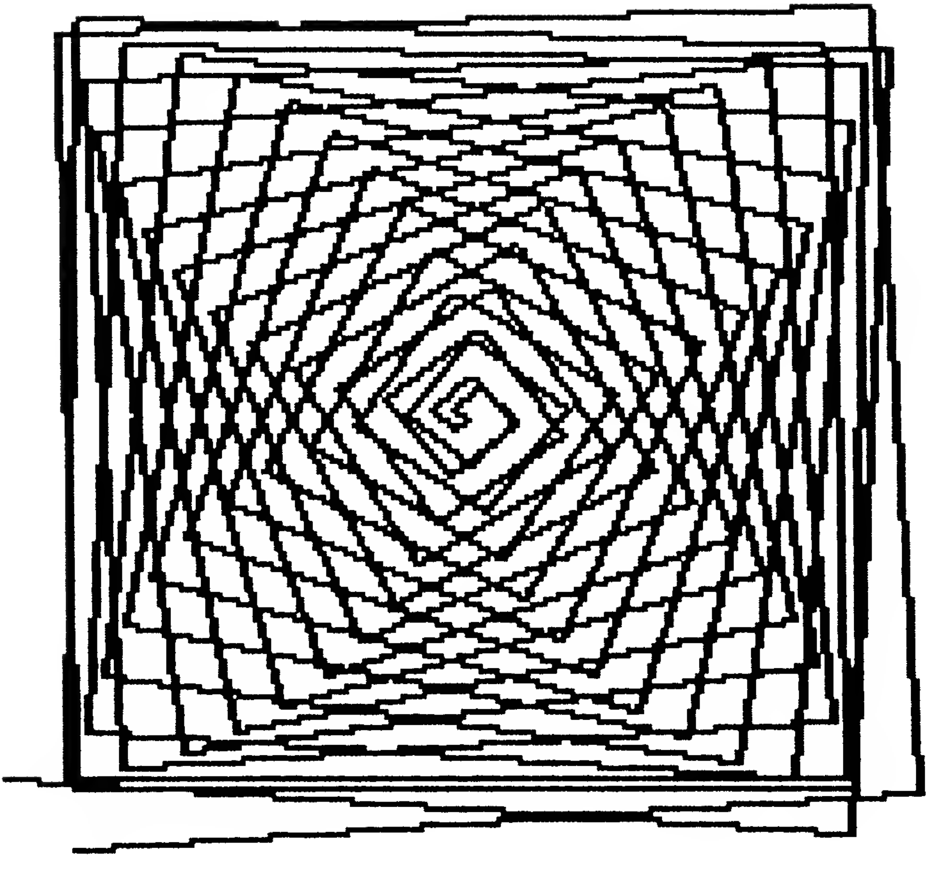

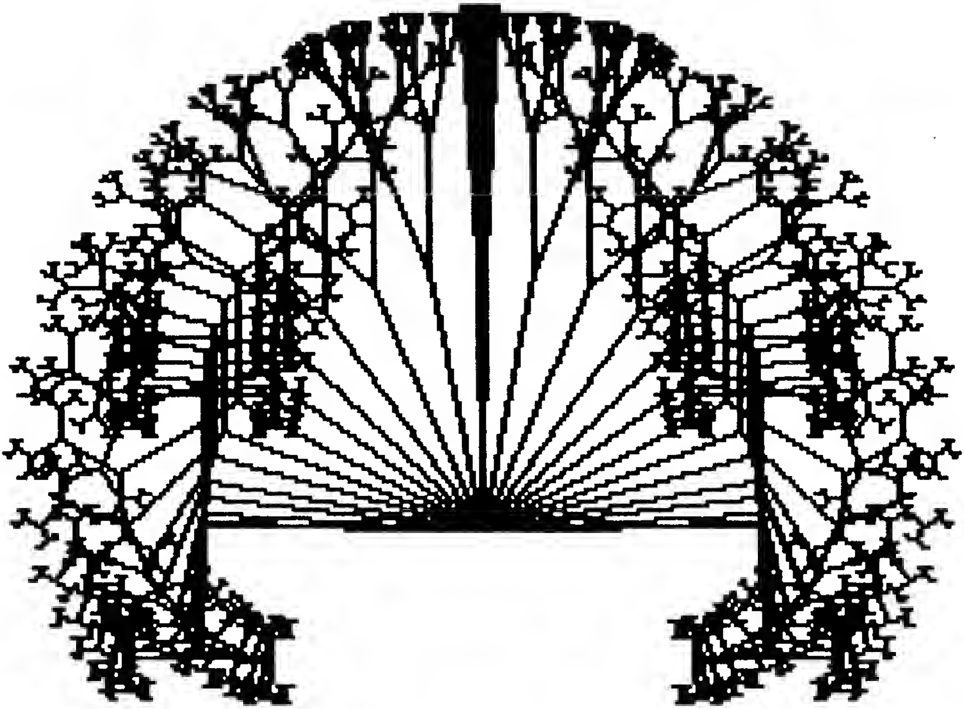

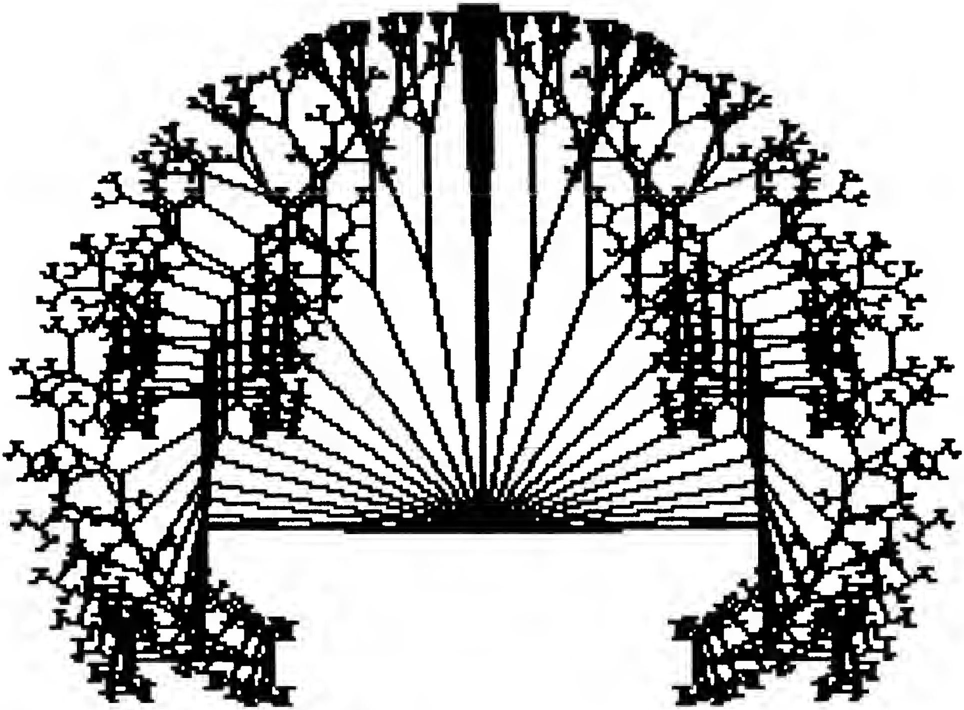

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About the author:

David Thornburg is a designer, inventor, and author who has made significant contributions to the human-computer interface. In the many articles that he has written, David emphasizes the special relationship between man and his machines ... that man's integrity, rather than being reduced by his machines, is enhanced through awareness and proper use. In **Coloring Series I: Geometric Designs**, our awareness is focused on the creative process that uses computer-generated graphics to study and enjoy symmetry, order, and design. As is typical with David's style, it can be enjoyed by children and adults alike.

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